

Evoking Presence through Creative Practice on Peppers Ghost displays

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Abstract:

This thesis proposes a theoretic framework for the analysis of presence research in the context of Pepper's ghost. Pepper's ghost as a media platform offers new possibilities for performances, real-time communication and media art. The thesis gives an overview on the 150-year old history, as well as contemporary art creation on Pepper's ghost with a specific focus on telepresence. Telepresence, a concept that infused academic debate since 1980, discusses the topic of remote communication, perceived presence transmitted through networked environments. This discourse of telepresence revealed shortcomings in current analytical frameworks. This thesis presents a new model for presence in the context of my research. The standard telepresence model (STM) assumes a direct link between three fundamental components of presence and a measurable impact on the audience. Its three pillars are conceptualised as presence co-factors immersion, interactivity and realism, presented individually in the framework of my practice.

My research is firmly rooted in the field of media art and considers the effect of presence in the context of Pepper's ghost. This Victorian parlour trick serves as an interface, an intermediary for the discussion of live streaming experiences. Three case studies present pillars of the standard model, seeking answers to elemental questions of presence research. The hypothesis assumes a positive relationship between presence and its three co-factors. All case studies were developed as media art pieces in the context of Pepper's ghost. As exemplifiers, they illustrate the concept of presence in respect of my own creative practice.

KIMA, a real-time sound representation experience, proposes a form of telepresence that relies exclusively on immersive sound as a medium. Immersion as co-factor of presence is analysed and explored creatively on the Pepper's ghost canvas. Transmission, the second case study, investigates the effect of physical interaction on presence experiences. An experiment helps to draw inferences in a mixed method approach. The third case study, Aura, discusses variations of realism as presence co-factor in the specific context of Pepper's ghost. The practical example is accompanied by an in-depth meta-analysis of realism factors, specifically focusing on the intricacies of Pepper's ghost creative production processes. Together, these three case studies help to shed light on new strategies to improve production methods with possible impact on presence in Pepper's ghost related virtual environments – and beyond.

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List of Publications:

Gingrich, O., Renaud, A., Emets, E.: Transmission: a telepresence interface for neural and kinetic interaction. Leonardo MIT Journal for Art, Technology and Science & Siggraph 2014 Proceeding Pages 375-385

Gingrich, O., Renaud, A., Emets, E.: Transmission - Sonifying, Visualising and Analysing Neural Activity through Telepresence. Electronic Visualisation and the Arts (EVA 2014)

Gingrich, O., Renaud, A., Emets, E.: KIMA - a holographic telepresence environment based on cymatic principles. MIT Press: Leonardo - International Society for the Arts, Sciences and Technology published by the MIT Press.

Gingrich, O., Renaud, A., Emets, E.: KIMA Enhancing Presence - Immersive Sound Environments as Presence Generating Factor. EVA - Electronic Visualisation and the Arts EVA 2013

Generative Art - Interactive Art: Delineations, Crossovers and Differences. Generative Arts 2012.

Introduction:

A photo-realistic hologram of the Spanish ambassador to Germany is streamed in real-time from Berlin to Madrid. A prime ministerial candidate appears live to an estimated audience of 100 million, in 120 locations at a time as a photo-realistic hologram - winning parliamentary elections of the biggest democracy in the world. A concert of rapper M.I.A in LA is performed simultaneously with the artist Janelle Monae in New York, both singing together in real time as photo-realistic holograms. Since Dr. John Pepper's days, Pepper's ghost has continued to provide a platform for spectacle, constantly changing its play form. All of these telepresence installations are perceived 3-dimensional, photorealistic live streams. All of this would have been unthinkable 20 years ago. Increased streaming bandwidth, ever improving camera resolution, better chip and sensor technology combined with developments in projection technology are leading to huge advances in telepresence experiences.

Pepper's ghost, a Victorian parlour trick, has been successfully used in the arts and in corporate contexts to convey photorealistic presence across long distance networks. Performers, presenters and artists appear as convincing real-time stream side by side to live on-stage performers. Through the lens of Pepper's ghost (PG), such remote presence is experienced as a 3-dimensional illusion, generated in an iterative process covering various different elements of audiovisual production. This research focuses on three key aspects of this production process and explores new strategies to further augment experiences in the context of my own creative practice.

The concept of illusion and perceived non-mediation is at the heart of contemporary presence research (Lombard & Ditton 1997; Biocca 1996). Within a Pepper's ghost projection setup, the medium and its apparatus virtually disappear. Technology recedes

behind the image itself. Pepper's ghost enables real-time interaction with a virtually projected image. Performers thereby merge with the virtual projection in a physical stage environment. The screen itself disappears entirely. Pepper's ghost offers a unique virtual environment, a blank canvas for presence research. The purpose of this study is to assess the effect of three key variables of presence generation -immersion, interactivity and realism. As co-factors of telepresence, their discussion opens new avenues for improved presence experiences in the context of my work.

A mixed method approach is employed to investigate this complex phenomenon on multiple layers: On a technical layer, presence is explored through quantitative means such as surveys, an experiment or a meta-analysis. On a qualitative, more subjective layer, the subject is approached through interviews, questionnaires, focus groups and observation. Concentrating on questions of media design and media creation, this thesis aims to contribute to the optimization of PG-telepresence in all of these three key areas sustainably. Through the lens of a proposed theoretic model, applied research paves the way for new artistic and creative avenues.

With the development of an overarching framework, and its practical application, I am proposing strategies to augment, develop and ultimately capitalise on new forms of telepresence. My own scholarly and professional background in Fine Art, Digital Art and Communication Studies informed the research academically. Corporate practice at formerly Musion Systems now MDH Hologram, one of the market leaders in Pepper's ghost projection, nourished the intention to develop new strategies for artistic and exploration. As art director at MDH Hologram, I worked closely with individual artists and art collectives in recent years. It is in this field, that I locate the biggest drive for innovation. In 2008, I founded Musion Academy - a forum for artistic practice within Musion that allowed artists to experiment with Pepper's ghost. Analema Group is the art collective I collaborated with most closely over the last 5 years, joining the team in 2013 as a producer. All three case studies were created in conjunction with Analema Group. A full breakdown of contributions is published in the appendix. Without their support, Evgenia Emets' artistic vision and Alain Renaud's talent and productive enthusiasm, this research would not have been possible.

The thesis discusses contemporary concepts of mediation, telepresence and streaming, their validity, their underlying components and their practicalities in the context of PG displays. Through the analysis of existing literature, I developed my own theoretical perspective: The proposed standard telepresence model (STM) focuses on three key components as elemental pillars of presence in respect of my creative practice. An existing body of research in fields as diverse as engineering, psychology, communication studies, hitherto failed to find a conclusive, coherent classification model with clearly

identifiable components. Furthermore, recent criticism concerns the sustainability of a conceptual basis for such presence co-factors. Preeminent researchers criticize the objectivity of measuring instruments as much as the cohesiveness of an overarching model (Floridi 2005, Slater 1999, Slater 2007). The STM framework proposes an alternative conceptual structure for the analysis and discussion of presence within the context of my own practice.

The STM framework is segmented into three co-factors of presence - interactivity, immersion and realism, echoing and synthesising existing research strands (Witmer & Singer 1998, Freeman 2004, Lombard & Ditton 1997). On a practical level, three case studies focus on these aspects individually. Respectively, they explore key variables of my hypothesis. Ultimately, all three case studies are intended to lead to new developments in presence experiences. The thesis is structured into a theoretical, conceptual part and a practical, applied part: My research question scrutinises the existence of a positive correlation between presence and the three co-factors interactivity, immersion and realism. All case studies analyse this relationship through a mix of exploratory and explanatory questions. Such a triangulation of methods facilitates the investigation of practicality of co-factorial concepts outlined in my thesis. The STM-framework and its three corollary pillars build a theoretic support structure to verify the hypothesis. Assuming a positive correlation between presence and its underlying components, a higher degree of any of these co-factors would correspond to a higher degree of presence.

Pepper's ghost offers opportunities in virtual representations for artistic and commercial applications no other screen media entails. Through the use of optical cues, methods of reflection and refraction, this projection technique creates the perception of 3-dimensionality without glasses. The invisible screen interface renders planar projection secondary. In essence a sophisticated optical illusion, Pepper's ghost provides a unique display method for telepresence due to its immersive character, the multitude of possibilities for interactivity and its potential for unchallenged realism. My thesis reaches out to a core target audience of media art scholars and digital art practitioners, and is clearly embedded in a media art specific discourse. Furthermore, a technical, industrial and commercial background informs this research. In my own professional practice in PG-telepresence and streaming applications, artistic research has long inspired my commercial projects. Vice versa, commercial activities and professional workflow largely influenced my media art practice as well as the theoretical prism of my thesis.

With 9 years of professional experience in the field of Pepper's ghost displays, my practice builds the background to this thesis. As an international company, MDH Hologram (formerly Musion Systems) has partners across the globe from China, to the

Emirates, from India to the US. London has long been its international headquarter and continues to be a central hub in the planning, execution and development of hologram events. With currently around 15 employees (October 2015), the UK has a central position within the international reseller network. Clients range from fashion to telecom companies, from pharmaceutical to broadcast, entertainment and telepresence.

On a secondary level, media art and the engagement with Analema Group throughout these case studies, has hugely enriched core aspects of my research. As founder of Musion Academy, the forum for academic and artistic discourse for PG display systems within Musion, I have worked with artists on a multitude of different telepresence projects over five years. Analema Group, and the collaboration with its artistic director Evgenia Emets and my supervisor and mentor Alain Renaud, has influenced my own work over this period. All three case studies were developed as collaboration with Analema Group. They present an artistic extension of this research, with a specific focus on furthering theoretical knowledge on telepresence. My role as producer and researcher allowed for a concentration on key aspects of telepresence relevant to this thesis.

KIMA, the first case study, concentrates on immersion, specifically immersive sound as a means of augmentation for telepresence experiences. KIMA is partially an art project, and in parts research design. KIMA was first developed by the core team of Analema group, and has been shown twice at London's biggest festival for kinetic art - Kinetica. KIMA was also presented at Siggraph and EVA London, the International Youth Arts Festival Kingston as well as at the ICT at London's Watermans Centre. Furthermore, KIMA has been published in the academic journal Leonardo (MIT Press) and in Siggraph and EVA proceedings. The results of this first phase of KIMA was presented by Analema Group at the Bournemouth University's Festival of Learning at Bournemouth University, at Union Chapel, London, in March 2015, and at the London Roundhouse in August 2016. All three events were supported by the Arts Council England.

The intention of the sequential mixed method study KIMA is to test the theory provided by the standard telepresence model that relates the concept of immersion (independent variable) to presence (dependent variable). A pilot study examined exploratory questions through a triangulation of quantitative and qualitative methods: A second, more explanatory phase, conducted at the Festival of Learning at Bournemouth University, followed up with participant observation and a structured survey. This mixed method approach guaranteed a degree of theory building and ensured academic inter-comparability. Combining qualitative and quantitative methods sequentially broadened the understanding of immersion in the generation of presence in the context of my practice. Both phases converged quantitative, numeric data with qualitative data (observation, focus groups). KIMA doubles up as art and research project, yet the

underlying objective remains the same across both spectres - to gain deeper insight into the effect of immersion on presence experiences.

If the first case study focused on immersion as co-factor of presence, the purpose of the second case study, Transmission, is to examine the role of physical interactivity in telepresence. The Transmission experiment combines motioncapture with brain wave analysis, providing biometric data on the effect of kinetic interactivity. This second case study analyses telepresence and its underlying component interactivity through a mix of quantitative and qualitative research methods: Quantitatively, the effect of presence is measured with an EEG (Electroencephalographic) input device. This experimental data is correlated with qualitative research data generated by interviews and participant observation. The intention of the second case study "Transmission" is to understand if and how interactivity influences perceptions of presence. Brain wave data is used to investigate the relationship between interactivity as independent variable and presence as dependent variable. Interviews with participants, observations and experiment data were triangulated with these research results. The project received Fusion funding by Bournemouth University for two framework conferences on brainwave visualisation strategies in the context of the Arts. The British Computer and Arts Society accepted a paper on Transmission to their annual conference EVA and the project was also presented at Siggraph 2014 and the impact factor journal Leonardo (MIT Press). Furthermore the project was presented at Kinetica Art Fair 2014 and shown at the Transmission Symposium at Bournemouth University in February 2015.

A third project, "Aura" proposes holographic displays as an introspective instrument to convey a different form of realism. Realism is introduced as fidelity of facts, rather than pure visual representation. Aura offers a humouristic take on the spiritistic context Pepper's ghost originated in, the ideas of ethereal presence. Technology replaces magic across different cultures. Aura discusses realism as key component of presence through its very negation. Aura, co-developed by Analema Group, translates realism as a subjective human idiom that isn't limited to mimesis. To the contrary, in this context the notion of realism extends to the invisible. Aura was presented at the Festival of Learning in July 2015 and subsequently at Kinetica's Gravity show at London's "The Hospital Club" in Covent Garden, a show curated by the artist Dianne Harris. In the theoretical part of this case study, I discuss key components of realism through a two-tiered meta-analysis. Converging qualitative and quantitative data, an expert survey and participant observation, I applied these findings to the specific context of Pepper's ghost. Three case studies discuss the phenomenon of presence through a practice-based lens, with a focus on the art of creation. The aim of this thesis is to present new strategies for optimisation of presence experiences on the canvas of the Pepper's ghost in the context of my practice.

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First and foremost I want to thank my mentor Alain Renaud and my colleague Evgenia Emets for their incredible contribution to this thesis. The collaboration with Analema Group on the artistic creation of the research projects has been an inspiring, life-changing journey. None of these projects would have been achievable without the incredible input of my supervisor Alain Renaud, the artist Eugenia Emets, and the CDE – Center for Digital Entertainment. Dan Cox and Zoe Leonard have supported Analema Group and myself throughout the journey – I will never forget all the incredible help and support I have been given throughout. I also want to thank my secondary supervisor Zhidong Xiao, and Richard Southern for their advice as well as all the artists, creative coders and performers involved in the projects.

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Author's Declaration

Extracts of this thesis have been presented in the articles listed above. All works have been developed in conjunction with Analema Group, specifically Evgenia Emets, and Alain Renaud. Individual contributions are listed in the appendices. Open Source code has been used in the development of all three case studies. All three case studies have been publically presented, links to these presentations are provided in the appendix.

1.1 History of Pepper's Ghost

The history of Pepper's ghost is tightly interwoven with the history of cinema, its display forms and its origins. The birthplace of Pepper's ghost itself coincides with the home of the first cinema in the UK. At the Royal Polytechnic Institution, the Brothers Lumiere held their first public screening in the UK. The namesaker of Pepper's ghost was the director of the Polytechnic - Dr. John Henry Pepper. As original patent holder, the invention still remains attributed to him. As locus operandi, birthplace of cinematic artefacts of all kind, the Polytechnic Institution was unique: As hybrid of a Victorian alma mater and precursor to the London Science Museum, it provided a home for cinematic experiments, obscure inventions and spectacular magic lantern shows. Within this culture of technical creativity, spirit of technological avant-garde, Pepper's ghost quickly became a magnet for its audience. As Tom Gunning states, Pepper's ghost "achieved an enormous success and became part of the stage machinery of the late Victorian spectacular theater" (Gunning 2007, p.228).

Pepper's ghost stands in the long tradition of cinematic apparati, dating all the way back to Phantasmagoria, the zoetrope and most importantly the Magic Lantern. The first written record of the Magic Lantern dates all the way back to the Renaissance and to the German monk and researcher Athanasius Kirchner, who, in 1671, published the "*Ars Magna de Lucis et Umbrae*". Athanasius Kirchner, however, did not invent this pioneering projection device. The Magic Lantern was a variation of an apparatus described by Giambattista della Porta in "*Magia Naturalis*" of 1558 (Compare: Friedberg 2006). The invention, based on principles of reflection and refraction, circulated among academics and inventors across Europe. The Dutch inventor Christiaan Huygen or the Danish monk Thomas Walgenstein displayed Magic Lantern spectacles all over Europe. As an almost mythical, if not magical device, written records remain rare: In "*Dioptica Nova*", the Irish author William Molyneux discussed optical technological advances such as the telescope, microscopes and the Magic Lantern. In 1736, Abbe Nollet and van Musschenbroek, inventors of the electrical device the Leyden jar, created the first cinematic impact, developing moving slides for the magic lantern.

At the end of 18th century, Magic Lantern shows started to boom across Europe. The panorama was patented in 1787 by Robert Barker, and first presented at London's "Rotunda" on Leicester Square. In this climate of showmanship and the dawn of vaudeville theatres, the French showman Etienne Robertson (1763-1873) presented the Phantasmagoria to an audience hungry for visual spectacles. First introduced in Paris of 1799, this combination of Magic Lantern, smoke and mirrors, sound illusion and visual entertainment, featured all the characteristics that would make Pepper's ghost so successful. In England, Paul de Philipsthal exhibited the phantasmagoria as early as 1801: The illusion was created through the use of smoke and blurry images, different

layers of depth, scaled projections, sound effects, and a clever play of lighting. Conjuring moving imagery, these artefacts can be seen as precursors to Pepper's ghost.

In 1838, the Royal Polytechnic Institution opened its doors on 309 Regent Street. Initially chaired by Sir George Cayley, the father of aeronautics, the Polytechnic Institution was a home for innovations, optical trickery and peculiar inventions. It was a place where the public experienced the discoveries of its time in fields as diverse as physics, science, and manufacturing. As a draw for audiences of all social strata, the Polytechnic Institution can be regarded as one of the first public science museums of its kind. In 1843, only five years after the Polytechnic had opened with his "Grand Phantasmagoria", the inventor Henry Langdon Childe presented a new invention. The chromatrope (also known as Biscenascope) consisted of two revolving glass circles moving in opposite directions. Inventors and artists worked hand in hand at the Polytechnic, presenting optical illusions, spectacles, lectures, magic lantern shows and not at least theatrical illusions such as the ghost.

The Royal Polytechnic Institution operated on the crossroad between academia and popular sciences, staging inventions, technical discoveries and scientific experiments. Its goal was to pioneer inventions, but also to create a form of 'rational entertainment'. The Royal Polytechnic was launched in 1838 as a response to Fachhochschulen in Germany, French Polytechnic schools and the Rensselaer Polytechnic Institute in the US. At the heart of the institute was the Great Hall. Fully equipped with lecture halls, theatres and an exhibition space to showcase experiments, the Great Hall presented science between academia and cultural spectacles with a predominantly popular angle. With its prime location in Upper Regent's Street, the Royal Polytechnic Institution combatted the reputation of trivializing science, all the while popularizing and furthering innovations.

Dr. John Henry Pepper was handed the title honorary professor after successfully presiding over lectures, showcases and theatrical plays at the Polytechnic. In 1840, at the age of only nineteen years, Pepper already held lectures on chemistry. In 1847, he lectured at the Royal Polytechnic Institution and only three years later he was appointed its director. In the Great Hall, he presented exhibitions of scientific artefacts to the public. These exhibits combined exponents of the second Great Exhibition at Hyde Park with new inventions in optical trickery. Professor Pepper was a gifted public speaker, popularizing evening lectures at the Great Hall, contributing to the Polytechnic's success. (See: Brooker 2009). Edmund Wilkie, one of the master slide makers at the Polytechnic reports on Dr. Pepper's role at the Institution: *"Dr. Pepper was by no means a designer or exhibitor of views or effects. He came first to the polytechnics as professor of Chemistry, and being a splendid lecturer and what is quite important a a good business man, was eventually elected managing director, and during his term of office produced many very successful illusions."* (Brooker 2009, p.189)

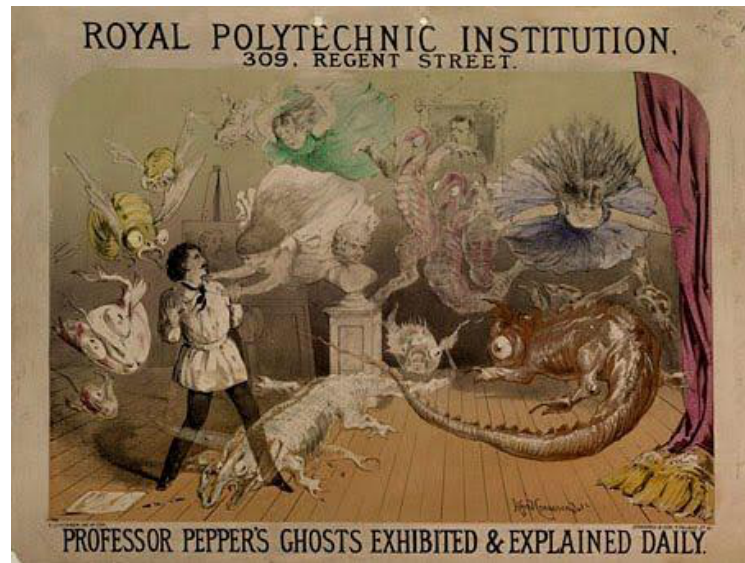


Fig.1 Poster for Dr. Peppers Ghost Lecture

As his lasting legacy, Dr. John Henry Pepper is credited with popularizing “The Ghost”, this Victorian parlour trick that was to delight generations to come. The Polytechnic Institution featured a 25 feet screen in use at the Large Theatre presenting Magic Lantern shows - almost entirely to the amusement of the Victorian audience. In 1862, Dr. John Pepper came across a new optical illusion for entertainment. A discovery by the retired Civil Engineer Henry Dircks promised to change the possibilities of screen spectacles of this time. Dr. Pepper contributed immensely to the promulgation of science, while demystifying spiritualism, by explaining visual phenomena to the public. His writings -as much as his lectures- served the popularity of academia and the dissemination of knowledge. Spectacle and showmanship was not much more than a means to an end at the Polytechnic. Dr. Pepper’s declared goal was to convey insights into the functionality of optical illusions, while mesmerising his audiences in ever-new ways. Following a great Victorian tradition, dating all the way back to the Great Exhibition, the display of illusionistic artefacts educated and entertained the audiences of the era.

The Ghost at the Polytechnic Institute

Pepper’s ghost as the technology became known, has continued to write history as a technology of spectacle. The development of Pepper’s ghost is well documented, not only by the founders and original patent holders themselves, but also by the academic circle in which the invention first emerged. “Pepper’s ghost” (PG) is a projection method that uses reflection and refraction to convey the illusions of spatial perception in a live stage environment. Its original invention is attributed to Henry Dircks, who first presented his development before the British Association for the Advancement of Science.

Dr. Pepper was first confronted with a model of Henry Dircks' invention "The Aetherscope," a new form of stage illusion, shortly before Christmas 1862. Magic Lantern shows had long been part of the repertoire of the Polytechnic Institution, and Dr. Pepper was looking for new techniques to conjure visual spectacles. According to Dircks, the first appearance of the ghostly illusion was subsequently showcased to a selected audience on Christmas Eve 1862. Badly concealed, the installation was set up using a sheet of glass of about 9 feet x 15 feet, drapes, a stage and a pit, in which the ghost actor was performing. Initially, the performer was clearly visible to the audience, yet the installation became an instant success. In Dr. Pepper's own words, he went to the patent office only a day later to file a patent in his and Henry Dirck's name. This installation first opened to the public a few weeks later with Charles Dickens' "The Haunted Man" in what can be seen as a Victorian form of "telepresence" - a ghostly apparition in a remote location.

To accommodate the success of what came known as "Pepper's ghost" at the Royal Polytechnic Institute, the apparatus soon transferred to the "Large Theatre". This big theatrical space at the institution's premises in Upper Regent's street was dedicated to lectures on optical illusions and theatrical performances. The play opened to the public by Easter Monday the 6th of April 1863. The large theatre already housed several magic lanterns along with the Great Disc – a giant projection screen. Years later, the Brother's Lumiere would stage the first cinematic screening at the Large Theatre in 1896, fifteen years after the Royal Polytechnic formerly closed down. In 1863, the Royal Institution profited enormously from the Dr. Pepper's ghost. The success and stream of visitors justified the scale of the installation. Dickens' "The Haunted Man" ran for fifteen months and was seen by about 240,000 visitors.

As its most prominent guests, the Prince and Princess of Wales became patrons of the Royal Polytechnic Institution. The physical setup of Dr. Pepper's ghost consisted of a big sheet of glass, angled at 45 degrees and two separate stages: one concealed from the audience's field of view, the other visible to the spectators. The reflective, yet light transmitting glass pane served as a medium to refract the ethereal projection – described by Dr. Pepper as "a phantom" (Pepper 1889). The illusion thus generated demonstrated ethereal characteristics. The Royal Polytechnical Institution's Large Theatre featured a projection box from which light could be targeted at an actor on a secondary stage. The actor performing on this hidden platform, illuminated with vast amounts of light, would refract in the sheet of glass onto the primary stage. The resulting reflection ultimately remained the only image visible to the audience in the auditorium. This ghostly apparition -now known as "Pepper's ghost"- delivered a sense of three-dimensional presence to visitors.

This ghostly reflection, the illusion of presence, was heralded by Dr. Pepper's as a theatrical spectacle, and was received with instant success. Glass simultaneously transmits and refracts light. If suspended at 45 degrees, the underlying image refracts at the same distance to the primary *plane*. The more lighting conditions between stage environment and projection "pit" are varied, the more pronounced is the effect. The illusion of ghostly apparitions can thus be created through careful adjustment of lighting conditions, until on stage interaction is perceived to be at par with the illusion. During the Victorian era, the time of spiritualism and Dickens' ghost stories, the presentation of ghost like delusion had an enormous impact on the audiences - specifically at the Royal Polytechnic Institute. Thirty years before the first cinematic screening, the sensation of moving images astonished, amused and entertained the public.

A constant stream of visitors to the Polytechnic was testimony to the Ghost's success. Even the Prince of Wales and his entourage witnessed one of the performances of Von Weber's "The Freischuetz" (Rhys Morus, In: Fyfe & Lightman 2007, p.362) at the Polytechnic. The success of Pepper's ghost was soon emulated by a number of theatres across London. Alongside the Polytechnic's rendition of "The Haunted Man", "A Christmas Carol" and scenes from "Hamlet" were performed. The Britannia opened with the play "Faith, Hope, Charity" (1863), written specifically for the illusion. Six months later, the West End's Adelphi opened with its own version of Dicken's "The Haunted Man" – now shortened to three scenes. And the success of the Pepper's ghost illusion travelled across the country to the Free Trade Hall in Manchester, the Merchant's Hall in Glasgow, and the Crystal Palace in London. The same year, the first Pepper's ghost apparatus was installed in New York City at Wallack's, in Brighton at the Theatre Royal and the Théâtre Impérial du Chatelet in Paris. The biggest Pepper's ghost of its time, the Paris installation measured five yards square (Carlson p.40 In: Luckhurst & Morin 2014). Yet most installations were shortlived: At the Wallack's in New York, the run of "True to the Last" closed after only two months.

In retrospect, the year of 1863 proved to be the Ghost's apogee. The apparatus was not only offering exciting possibilities for the West End, but was also perceived as rather inconvenient to orchestrate: An installation planned for the West End's Drury Lane theatre was abandoned at the eleventh hour. Firstly, the size of glass required to fill a stage was still hard to manufacture, let alone to transport or to keep clean. Once set up, the installation was not easily removed. The number of plays featuring ghosts and thus enabling the creative use of the medium was still limited. Duration of scenes featuring the "ghost" hardly lasted longer than twenty minutes, even if artificially extended, as was the case in the "The Haunted Man". Another obstacle was the need for an incredible amount of light required to render the illusion convincing. This in turn resulted in an extreme amount of heat radiation. Actors and technicians referred to the pit under the stage as the "oven" (Steinmeier 2003, p. 35) Equally, sound failed to travel through the glass sheets,

meaning that performers effectively had to mime when standing behind the screen (ibid). In short, as much as the apparatus' effect was deemed exciting, it was perceived as too cumbersome to be included in the production process in other West End theatres. The illusion experienced a brief hiatus, and disappeared from major West End shows, to become a peculiarity of countryfairs and magic illusions, first in England and then abroad.

Ghost shows toured the British countryside at the end of the 19th century. Records indicate the continued use of Dickens' stories like for instance "Adrian the Betrayer" (Compare: Carlson, 2014 p.42). And around the turn of the century, the ghost show conquered the American continent's fairgrounds. In 1903, for thirty weeks the London ghost show was the Robinson Carnival Company's most successful feature (Nickell 2005, p.291). Pepper's ghost quickly became a magicians' tool and was masterfully integrated into some of the fairground's most exciting attractions. A high degree of artistic and technical specialisation was required to assure its impact. A large amount of trained people was needed to assure its effective use. As the magician and showman Ament observed, "not one in 50 can run a ghost show after being shown how" (In: Nickell 2005, p. 289). Technical innovations and the rise of different forms of projection methods led to a steady improvement of Pepper's ghost and ultimately its re-invention as a cinematic environment.

Alabastra and the Vienna Kinoplastikon

Dr. John Pepper's initial patent gave way to technological, commercial and artistic exploitation. The rise of film across Europe revolutionized the possibilities Pepper's ghost offered as a projection medium: From 1909, the German engineer August Engelsmann patented various variations of the Pepper's ghost illusion. Pepper's ghost played a brief, but significant role in dedicated movie theatres. The entrepreneur and inventor Oskar Messter introduced the technology as a screen add-on. Under the name "Alabastra" (Loew 2013, p.3), the illusion conquered first German and Austrian movie theatres. As a means to overcome a commercial crisis in the German film industry, suffering from overproduction, this new form of cinematic experience was to combat the looming crisis. Messter, who had earned his fortune through the production of sound film, concentrated on new tools of cinematic expression such as the Alabastra. Alabastra mostly pictured musical performances of up to four minutes, which equaled the maximum duration of a phonograph recording, entertaining a large audience with short visual spectacles on a Pepper's ghost device.

Stages were modular, and depicted specifically produced films. As such the Alabasta was very similar to present day Pepper's ghost projections. Performances were not only limited in their duration, but also in the height of performers due to the limited screen size. Limitations in glass production restricted screen projections to one meter maximum. Alabastra was initially recorded in black and white. Later on, some of the films were

coloured by hand retrospectively. Combining stage performances with cinematic experiences, Alabastra was a true precursor to present day Pepper's ghost. From its inauguration around 1909, to its demise at around 1914 in the wake of WWI, Alabastra's success was rather short lived. Despite favourable reviews and apparent audience appreciation, its maintenance was not profitable enough, not at least due to high production costs and the small number of theatres equipped with Pepper's ghost setups.

A sibling of the Alabastra, the Vienna Kinoplastikon was even more successful. While Alabastra remained confined to the German speaking market, the Vienna Kinoplastikon experienced international repercussions. In 1911, the Austrian showmen Karl Juhasz and Franz Haushofer opened their Kinoplastikon theatre in Vienna, modelled on Messter's technology. Their patent, filed the same year with financial support from the aristocracy, modified Messter's original patent. In a major improvement, the new patent enabled life-like and life-sized projection. This development ensured a commercial success, before intellectual property was even granted.

From 1912 onwards, the majority of films for Kinoplastikon was produced by "Wiener Kunstfilm", which held a quasi-monopoly due to specialisation. Despite being shorter than normal cinematic performances, Kinoplastikon films were priced significantly higher than standard admissions. The Kinoplastikon targeted the middle classes, white-collar employees who were interested in stage and screen spectacles. Its success in Vienna quickly conquered the rest of Europe: In 1913, 250 Kinoplastikon theatres existed in the United Kingdom, Russia, Italy, opening in Paris in January 1914 (Loew 2013, p.5) and a year later in the United States.

The rise of cinema also led to the inclusion of Pepper's ghost in the production processes of film, most notably Fritz Lang's "Metropolis" in 1927. The filmmaker Cecil Hepworth bridged the gap between Dr. Pepper and pre-war Pepper's ghost productions in the UK, recording a number of "Alabastra" films himself. As Loew points out, the enthusiasm for spatial cinematic experiences increased in a time of economic decline due to overproduction for the feature film during the 1900s. In the United Kingdom, and on the continent the fascination with these new forms of 3-dimensional spectacle created a niche market for Pepper's ghost. Projected performances were received as a form of live theatre: Audiences frequently clapped and responded to the screenings as if they were observing a live spectacle (compare: Loew 2013 p.101). This second wave of success for Pepper's ghost was cut short by the start of World War I in Europe.

But it wasn't for another 50 years that the invention caught up with the masses again, in Britain as well as abroad. During a postwar period of reduced Pepper's ghost productions, the technology remained almost exclusively in the realm of amusement parks and attractions. The "Girl to Gorilla" illusion was conceived in the 1960s as part of Hank Renn and George Duggan's show for Carl Sedlmayr's Royal American Show. In the

1970s, the show was adapted to become “The Girl in the Goldfish Bowl” an illusion that depicted a mermaid in a glass bowl, shrunk down to the size of a goldfish (Nickell 2005, p. 292). Both illusions required a significant amount of preparation, staging, as well as physical labour and know how.

At the same time, amusement park’s discovered the invention: Disney’s Harper Goff sketched first designs for Disney Land’s “*Haunted Mansion*” as early as 1951. However, it took eighteen more years before the attraction finally opened to the public, notably due to other engagements of Disney’s “imagineers” during the World Expo in New York City (Mumford 1993). Walt Disney empowered his “imagineer” Ken Anderson to finalise the designs of the “Haunted Mansion”, initially planned as a walk-through experience. The task to create the ride itself was given to Disney’s “illusioneer” Yale Gracey and imagineer Rolly Crump. The popularity of the attraction had led to the introduction of a “Doombuggie” trolley system to allow a faster flow of people. The large scale Pepper’s ghost illusion can be seen as one of the main attractions of the Haunted Mansion, created through motorised puppets, moving on a revolving track. These animatronics reflect in a hidden mirror, cleverly integrated into the architecture. Glass of 30 feet diameter is suspended in front of a ballroom, with ghostly reflections emanating from underneath and above the audience’s pathway. Glass of such a scale had only recently become available. The “Ballroom” soon became one of the key attractions of Disney Land and was emulated in the Disney World Florida, Tokio and Paris amusement parks. Throughout the 1960s and 1970s, Pepper’s ghost played a niche role as attraction on the fringes of museums and amusement parks. The London Science Museum installed the James Gardner designed “Changing Office” attraction in the mid-seventies, magically transforming an office from 1970 into an office space of 1870 and back. In the 1990s, Pepper’s ghost experienced a renaissance, heralded by another wave of technical innovation.



Fig. 2: Disneyland’s original *Haunted Mansion* Ballroom scene in 1969.

The German inventor Uwe Maass adapted the original invention through the use of a sophisticated rigging apparatus and a dedicated material to replace Pepper's ghost's biggest hindrance for commercial use: Glass, due to its fragility and weight, is difficult to setup and to un-install, let alone to transport. There are severe limitations in size due to production difficulties. The development of polymer foils as refraction/reflection material permits ease of transport, an unknown scale, ease of setup and ease of storage, but most of all, it ensures a different refraction index – resulting in a crisper and cleaner image than during the days of Dr. Pepper.

Uwe Maass' patent was filed in the late 1990s and conquered the world soon after. His first installation was produced with legendary creative producer Andre Heller: The Swarovski crystal world opened to the public in 1996. In the decades before Uwe Maass' patent, Peppers ghost had retreated to the fields of fairgrounds and amusement parks. With the new tensioning technique, the technology conquered new arenas of spectacle such as entertainment palaces (Friedrich Stadt Palast Revue Show 1999) or product launches (BMW Z-series launch, 2005). Soon, a scale of hitherto technically impossible dimensions became a possibility: The World Expo 2000 in Hannover spanned a Pepper's ghost setup of two times 76m x 8m in size. The patented projection method, using high brightness projectors or LEDs instead of directed light allows for an augmentation of the image through the use and integration of motion graphics, which can be displayed in real time into an on-stage environment. The experience of on stage presence -of telepresence- profits enormously from a controlled lighting environment, a dedicated codec solution and customized recording parameters.

1.2 Large Scale Pepper's Ghost Displays

Musion's Eyeliner is using a specifically developed, highly reflective, tensionable polymer foil, designed to replace glass in large-scale Pepper's ghost installations. There is no technical size limit to such foil based screens - in practice they have been up to 50m wide. A standard apparatus tends to stretch from 4 meters to 10 meters in width, with a depth of 4 meters to 7 meters. A typical image size, using a single projector, is approximately 5m wide by 4m high. The system incorporates a performance stage that is equipped with an integrated lighting solution, usually boxed with dark draping along the sides and back of the system. The polymer screen is placed at a 45-degree angle between the stage and the audience, and ideally completely disappears in show state. At least one high definition DLP (digital light projection) video projector is mounted in front of the foil, projecting onto either the floor or ceiling depending on foil orientation. PG-systems have been in use for large-scale telepresence solutions since 2008. Pepper's ghost projection obeys the laws of reflection:

- a) The incident ray, the reflected ray and the normal to the reflection surface at the point of the incidence lie in the same plane.
- b) The angle, which the incident ray creates with the normal is equal to the angle which the reflected ray makes to the same normal.
- c) The reflected ray and the incident ray are on the opposite sides of the normal.

Modern day Pepper's ghost utilises similar essential conditions as its Victorian predecessor. Lighting between staging, projection and audience area is varied carefully to create a sense of on-stage presence. A light beam travels from the projector to a primary surface, the reflection of which is being picked up in the screen -a transparent, highly reflective surface, which then refracts the image into a defined space. The projected image is literally mapped onto the physical parameters of the stage environment. Calculating of accurate measurements, i.e the relative height to the audience's viewing angle, the virtual space can be aligned with the parameters of the physical space – hence creating the illusion of depth perception. This sense of presence is conventionally pre-produced, but can be created in real-time, and equally across large distances. In 2008 PG-facilitated telepresence was launched as Musion Telepresence achieving life-sized, on-stage communication in real time between Bangalore India and San Jose California. In essence, this life-sized telepresence relies on the same physical principles as the original Pepper's ghost effect, yet uses proprietary Eyeliner screen technology and a dedicated codec solution for optimised signal transmission.

Musion – History of a Company

Technically, Musion's Peppers ghost installation differs from its Victorian predecessor through the use of a specifically developed polymer film instead of glass, high luminance projectors or LEDs instead of conventional light sources and an integrated lighting system. PG-telepresence uses an optimised live streaming signal transmission or satellite links. A number of visual cues and recording parameters serve the development of photo-realism in the production process. A bespoke lighting solution further enhances the notion of on-stage presence. With $2/10^{\text{th}}$ of a second, codec-latency between transcontinental broadcast venues is less than over a telephone signal, a fraction quicker experienced when compared to a regular international telephone conversation.

Musion launched their telepresence in 2008, after a pilot with Cisco Systems' John Chambers. Communicating in real time from San Jose in California to an audience in Bangalore, the event made headline news. The same year, its commercial inauguration aired on German national TV as a direct live stream between London and Berlin.

Technical advancements such as codec adaptations through extensive testing led to steady improvements of the offering. This research presents an effort to further these developments technically with the objective to generate an optimised sense of presence for user experience of real-time Pepper's ghost installations..

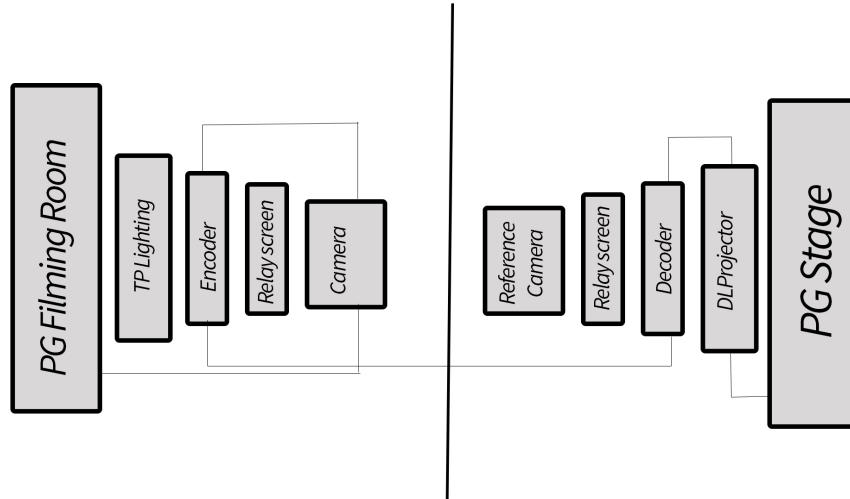


Fig. 3: Telepresence Setup, Flow-chart

Soon after its launch, PG-telepresence conquered the world: A telepresence stream between London and Infocomm, Florida (2009) saw a virtual presenter triggering motion graphics in real-time in multiple locations. In 2011, Orange's HelloDemain at the "Cit  de Sciences et de l'Industrie, Paris" allowed the public to be beamed into various scenic, virtual environments, from NYC skylines to the jungle. For the Vancouver Olympics, Musion streamed members of the Russian Olympic Committee of Sochi 2014 into the Russian pavilion. Recently, Narendra Modi won the largest election in the world, with over 1500 telepresence installations across India. The rapper M.I.A performed with Janelle Monae between Los Angeles and New York with both artists appearing in both locations at the same time. PG-telepresence derives directly from the 1860s Victorian parlor trick, using a number of technical innovations to create a photo-realistic, spatial communication experience.

Light refracting over a fixed surface into a defined space, contributes to the final result, ultimately providing an experience of presence. The phenomenon of presence has been discussed academically ever since the term was used first by Marvin Minsky in 1980. In order to arrive at a technical discussion of the term, we need to look at the three different dimensions of experience in which Pepper's ghost comes into effect.

- a) as spatial experience through on stage projection adding to the feeling of immersion
- b) as interactive experience through eye to eye contact adding to interactivity
- c) as a photorealistic experience through high definition recording and visual cues

The discussion of telepresence under these three premises derives from existing concepts and models of telepresence. The concentration on core components of telepresence provides a systematic instrument to analyze telepresence experiences across three case studies. The goal of this thesis lies in the development of new strategies for the augmentation, and visual effectivity of presence experiences. Understanding core elements of telepresence, measuring its effectiveness, can lead to new strategies to increase their impact.

The Oxford Dictionary (Purcher 2007, p.91) understands the term holographic as referring to a hologram – as such the term is descriptive rather than factual. Holographic projection is perceived as holographic i.e. relating to a hologram. According to the Oxford dictionary, a hologram is *“understood as a three-dimensional image formed by the interference of light beams from a laser or other coherent light source”* (Oxford Dictionary 2014) The Oxford Dictionary for Science Fiction however refers to a hologram as *“typically an intangible representation or image that exists in three dimensions, often controlled by AI and able to interact with its environment”* (Purcher 2007 p.90). Technically, holographic projection is very different from holography, which is defined as the reproduction of the amplitude and phase of light by diffraction. Despite obvious similarities between holograms and holographic projection, the two phenomena are technically completely different (compare: Blanche et al. 2010). In the context of this thesis, “holographic” refers to a perceived three-dimensional image projected into a physical space.

Merging a live stage environment with the field of cinematic effects enables new possibilities in digital art, video and performance. Blending the virtual world with the physical environment, seamless fusion between virtuality and reality creates a new visual vocabulary. From photorealistic representation of performers, narratives combining animation with live actors or real-time motioncapture - a new array of creative opportunities emerges. Holographic projection offers as many possibilities as it entails technical restrictions. Limitations require artists to redefine on-stage performances: And every production process starts with a focus on the user. An optical illusion only ever comes into effect, once user perception is taken into account. An optical illusion of depth perception requires specific production standards to be followed through. Thirdly, Pepper's ghost requires an iconographic visual language, constant movement and the focus on lighting in the consideration of the physical projection environment. It is through these limitations - perceptive, technical, and visual that artists are prompted to re-think their own creative practice and to explore new methods of visual representation.

the German inventor Uwe Maass founded Musion in his home city of Cologne in 1996. In an effort to redefine and revolutionise Pepper's ghost, Maass filed his own patent, involving the use of mylar foil over glass. His patent resulted in larger and more flexible

setups, soon leading to a series of pioneering projects. Maass moved to Dubai and launched an international network of resellers. Distributing the technology in markets across the globe, clients included automotive companies, amusement parks, as well as key players in the entertainment industry. The Millennium saw a first phase of expansion with London becoming a second headquarter. London remains the brand's most important operations and creative hub. A milestone achievement in the history of Musion was the 2006 Grammy performance of Madonna and the Gorillaz in Los Angeles, following the MTV EMA Awards in Portugal 2005.

For the young company, such global visibility of 20 million live viewers opened new doors. In this seminal year, a holographic presentation for Richard Branson's Virgin Digital launch further paved the way for international success. A renewed interest in the technology ensued - specifically in the run-up to the London Olympics 2012. The technology was employed to win the bid and launched the Olympic logo with David Beckham at the London Astoria in 2008. A hologram for HRH The Prince of Wales at the Masdar World Energy Summit made international headlines in 2009. In 2010, a marketing event for the Beijing Olympics was held simultaneously in four locations around the world. Soon after, the company launched its telepresence offering with the first holographic telepresence presentation between Bangalore India and San Jose for Cisco System.

Musion invested heavily in the development of telepresence for holographic presentations. In 2008, head offices moved from the heart of Covent Garden's Theatreland in Langley Street 7a to the representative Westcott House on 35, Portland Place. The move to the famous Regency building with its place in music history marked an era of expansion. A new financial director, Daren Hicks, was appointed. A technical director, Alex Howes joined the team, assuring that investment into the prestigious studio space would yield visible results. This phase of increased investment, technical innovation and internal transformation saw the birth of the Musion Academy, the company's artistic arm. Personally, I had the honour to spearhead the Musion Academy for five consecutive years. Telepresence and streaming capabilities became an increasingly important aspect not at least for the creative branch of the company. The first-ever televised telepresence event was held in August 2009. The photo-realistic real-time performance by singer Corinna Jess was streamed to an audience in Berlin. In 2010 telepresence connected the Vancouver Olympics with the Russian Pavillion, and a few months later the industry event Infocomm in Orlando featured live concerts by artists streamed out of the London. Musion Consultant, Producer Liz Berry, described the event as an important milestone in the history of the company:

"One of the most memorable events was lighting designer Mark Hanna as a TP hologram at InfoComm. We were having a 'backstage' moment, being exhausted and discussing upcoming shows as if we were both having a casual conversation in different sides of the same room. I bizarrely found myself getting annoyed at all his piles of cable on stage in London cluttering up my stage in Orlando on telepresence. It felt like he was really there, but he was in London and I was in Orlando. Light takes a 2D image into the 3rd dimension, fooling our brains into believing it's real."

The idea of simultaneously streamed holographic events continued to dominate the company's R&D and creative offering: In 2010, the global jubilee celebration for Randstad, one of the world's largest recruiting companies was held in 26 countries on four continents at the same time. And only year later, Mariah Carey performed "holographically" in four different locations at once. Forays in photorealism resulted in a higher degree of perfection, on an ever large-scale: The holographic fashion show for British fashion house Burberry combined a 360 degree projection with a 14-meter holographic catwalk. A showcase for the London Design Museum for Christian Louboutin featured a holographic performance by burlesque artist Dita von Teese, quickly becoming the institutions' most successful show to that date.

Musion's biggest media success however arrived with the holographic "resurrection" of late rapper Tupac Shakur in 2012. Tupac's holographic performance, developed by Dr. Dre, generated over 20 million youtube hits within three months of release and sparked international headline news. At this stage, the company spanned an international reseller network from Japan to the United States with a broad international client base. In 2013, the company was bought by Giovanni Palma who changed the company name into MDH Hologram, while keeping the Musion brand - opening offices on four different continents around the globe. MDH Hologram achieved break-through developments using LED screen technologies, which allowed for life-sized realism in bright daylight, for the first time in the history of the technology. In 2014, the premiere of the Hollywood blockbuster "X-men: Days of Future Past" featured 5 meter tall "X-men" as holographic sculptures. At the same time, the election in the largest democracy in the world broke all streaming records. Simultaneous holographic presentations of Narendra Modi reached millions of voters in over 120 locations at a time in 2014. For Giovanni Palma, the biggest milestone achievements in the history of MDH Hologram are the first permanent holographic installation in an airport, Milan Malpensa, as well as the joint venture with a large international hotel group with telepresence offerings from city to city. The company has continued to support its artistic endeavors with sponsorship for the Kinetica Art Fair or the Artist for Nepal network series. For the installation at the World Expo in Milan, MDH Hologram was awarded the Silver Award for best content among more than 150 participating countries Musion, now MDH Hologram as patent holder for large-scale Pepper's Ghost installation, has been home of artistic creation since 2008. Ever since, artists have been continuously invited to use the projection platform to engage in experiments with Pepper's ghost to develop their own visual vocabulary, technical strategies and artistic creations. Musion Academy has been displaying holographic projection art in the United Kingdom and abroad, at public and private digital art events. More than 300 artists have worked with the technology and experimented with its possibilities. Artists' engagements have been diverse in scope, covered genres as diverse as sculpture, performance, generative or narrative digital art.

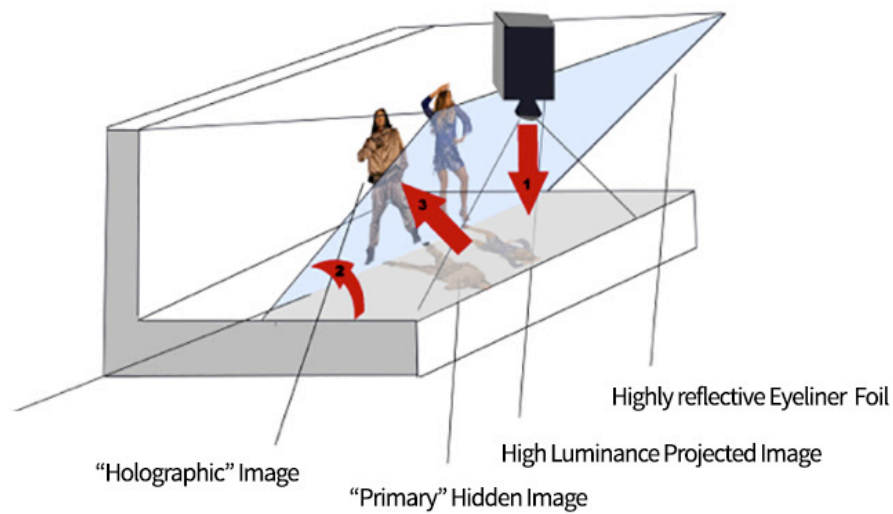


Fig. 4: Eyeliner Screen setup

1.3 Holographic Projection Art – The Musion Academy

Musion Academy was created as a forum for artists of all genres, backgrounds, and skill levels to explore the potential of this screen technology creatively. In 2008, Musion had moved to new premises at Westcott House on Portland Place, just as the technology reached new levels of visibility. The former IBC studios, later home to JetStudios the famous recording studio where Black Sabbath's Ozzy met Sharon Osbourne, where bands from the BeeGees, the Beatles or the Birds were produced and the Rolling Stones recorded their first album was the ideal environment to engage with artists creatively. Thanks to the discretion of the tolerating directors, the doors opened from 2008 onwards to artists and industry professionals to engage in an ongoing debate on the future and history of animation, kinetic art, cinematic production and stage-screen media.

Artists were invited to partake in a conceptual and creative discourse, produce pieces, exploring possibilities for performative interaction. Over five years, a series of lectures and presentations led to an era of artistic creation. Artists recorded their own holographic pieces at the studio's telepresence suite. Artistic presentations, talks and lectures were held on a frequent basis. From 2008 to 2013 Musion Academy built a forum for artists to exchange ideas and develop strategies. Musion's head offices at Portland Place built an inspirational backdrop for artistic creation. Filming workshops were held on weekends, giving artists access to the studio space to explore the intersection between stage and screen interactively.

Lectures from industry professionals such as Liz Berry (Rose Bruford College for Theatre and Performance), the artist Stuart Warren Hill (Hextatic / Holotronica), Kinetica's founder Tony Langford, Catherine Mason (Computer & Arts Society), Stop Trick Animation artists Sonia Vera, projection artists Sean Prickimage and many others opened the discourse on creative possibilities of this screen environment. Attendants of the Musion Academy included Birgitta Hosea, Course Director at the Masters program for Animation at Central Saint Martins (now head of animation at Royal College of Art), Jini Rawlings, lecturer at the Media Art and Design Lab at the University of Westminster, artists Evgenia Emets, cinematographer Laura Jean Healey, the artist Brendan Murphy. Pink Floyd's pioneering animation artist Ian Emes, the musicians New Opera Hero, acclaimed photographer Sheryl Nields, the artists Kira Zhigalina, Rachel Garrard, Madi Boyd, Gaelle Berton, Jonathan Munro & Gareth Goodison, James B.L. Hollands, Jayne Wilton, the artist and curator Jane Webb, the fashion designer Kinga Malisz (Tom Ford, Nina Ricci), are just a few of the participants who worked with the technology as part of Musion Academy. Attendants arrived from as far as India (Cheruwi Agrawal) or Los Angeles (Sheryl Nields).

The MAMAs – Musion Academy Media Awards

An annual showcase, the MAMAs or Musion Academy Media Awards, was held three times, twice at the birthplace of Pepper's ghost, the Royal Polytechnic Institution. Now, home to Westminster University's Old Cinema, the space was adapted with the help of an array of industrial sponsors. The Royal Polytechnic Institution and its academic context gave the MAMAs a sense of historic relevance. Artists such as Lewis Sykes and Ed Cookson (The Sancho Plan), techno-avantgarde performers New Opera Hero, and legendary pioneer Stuart Warren-Hill pushed the limits of creativity and technology alike. The MAMAs jury consisted of industry professionals such as British Computer and Arts Society founder George Mallen, directors of the company and a team of academics and artists awarded outstanding pieces in five categories. Proceedings went to two nominated charities. The MAMAs ambition brought a new technology to new audiences, combining the latest in projection technology and interactive arts with some of the most important pioneers in the field.

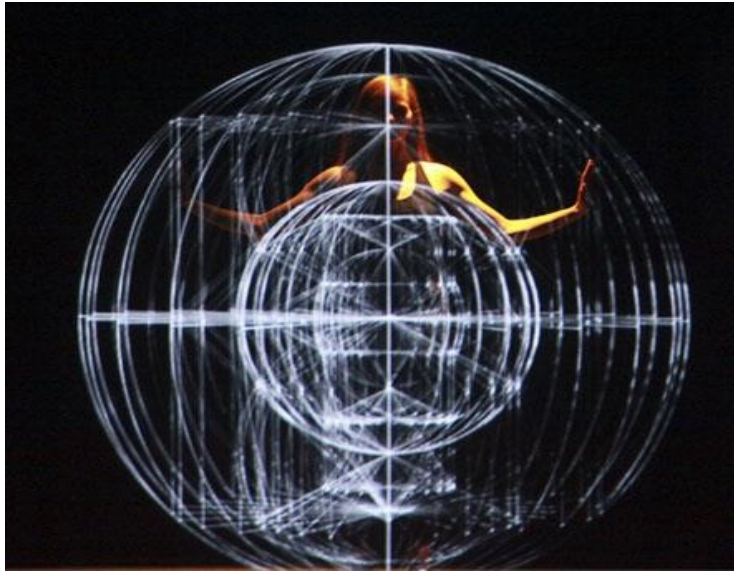


Fig. 5: Rachel Garrard - 7 Transmutations

The first Musion Academy Media Awards were co-orchestrated by the artist Evgenia Emets and myself in 2009, following a year of artistic creation at the Academy. The MAMAs received support by the technology's inventor -Uwe Maass- as well as a range of technical partners and the University of Westminster's Media Art and Design Lab. For the first time since Dr. Pepper's days, a large-scale Pepper's ghost display was installed at the historic cinema at the Royal Polytechnic, an installation designed by the production manager, Liz Berry of Rose Bruford College for Theatre and Performance. Among others the jury consisted of the Media Art historian Catherine Mason, George Mallen, co-founder of the British Computer and Arts Society, Mike Stubbs director of FACT Museum for digital art, the artist Imogen Heap and Kinetica Museum director Tony Langford, who shortlisted three artists competing for the audience's vote. Winners of the prestigious Grand Award included New York based artist Rachel Garrard with her hand drawn piece "7 Transmutations", Madi Boyd, then artist in resident at UCL, the multimedia avant-gardist Gaelle Berton and pioneering audiovisual artist Stuart Warren Hill. Rachel Garrard's "Seven Transmutations", combines pencil drawn stop motion animation with live interaction. Conceptually, the artist creates a new Vitruvian form – revealing sacred geometries as transcendent bodily layers of light. In the artist's words:

"Man is much more than his physical body. We are composed of layer upon layer of energy and consciousness. For the piece 'Seven Transmutations' a symbolic set of pencil line drawings have been mapped out to represent seven layers of the ephemeral body, and the seven stages of transformation the physical body must go through to transform itself into a body of light. Based on the human form's cosmic proportions and subtle energy systems, each drawing is a symbol of one of the invisible subtle envelopes that surround and interact with the physical body. Using holographic projection as the medium, the artist performs on stage within the projection, interacting with the perceived light systems."

The artist Madi Boyd, working closely with Beau Lotto's lab at UCL, portrayed the vivisection of a bee as an alarming call to action against the steady decline of bee

populations worldwide. The piece “Not I” by painter Brendan Murphy, based on Samuel Beckett’s play with the same name, featured a giant floating mouth as holographic sculpture. The multimedia artist Gaelle Berton reconfigured a console remote control to become a live drawing tool, in a motion controlled dance performance. Pioneer Stuart Warren-Hill showcased his signature project Holotronica on a new instrument –the Eigenharp- surrounded by real-time visuals responding to his concert. As winner of the audience vote and the Grand Award, Stuart Warren-Hill subsequently staged Musion Academy artists at the BFI Southbank and the animation festival onedotzero, where he performed together with New York based live drawing artist Shantell Martin and the VJ culture pioneers Dfuse. The MAMAs brought a sense of awe to the birthplace of Pepper’s ghost, converging the history of cinematic media with a renaissance in electronic arts.



Fig. 6: Stuart Warren Hill – Winner of the Grand Award 2009

In 2010, the MAMAs returned to The Royal Institution, hosting the first international VJ Award voted on by audiences in 26 countries on five continents. MAMAs Award winners included the techno-avantgarde group New Opera Hero, the Russian artist Kira Zhigalina, visual artists Jonathan Munro and Gareth Goodison and Madi Boyd. Kira Zhigalina’s “Ephemeral Lightness of Being”, presented a holographic dance performance, in which the artist’s movement resulted in real-time, kinetic light sculpture. Ki-Ra explored *“the concept of the human energy field as a shapeshifting colour trail temporarily created in collective space”* (Ki-Ra 2010). Madi Boyd’s award winning “Point of Perception” has since been shown at the Dublin Science Museum and the London Science Museum. Visionary photographer Sheryl Nields presented Dita von Teese as a stop trick animation. In a world’s first, New Opera Hero combined stereoscopic projection with the holographic screen interface, audio-visual real-time, facial animation with utopian soundscapes. Their piece “Work Eat Sleep” had to be censored for the VJ Award for audiences around the globe, but received the Grand Award at the MAMAs. NOH are the art collective most accoladed in the history of the Awards.

MAMAs 2012

The third and final MAMAs Awards were held at Kinetica 2012 and showcased outstanding pieces by Award winning artist Laura Jean Healey, the performance artist Madaleine Trigg, Analema Group's real-time fractal modulation "Khaos" as well as a performance by renowned Austrian visual artist Starsky. Prickimage, Sapolab and Dan Strutt showcased "Metaman", a real-time narrative dance piece performed by Joe Garcia. The animation pioneer Ian Emes (Pink Floyd's Dark Side of the Moon, Oriental Nightfish) presented a newly developed piece and the composer Barry Seamen's opera premiered holographic elements. Analema Group's "Khaos" raised the bar for interactive performance art with a real-time generated fractal form modulated through sound and movement by the artist and founder of Analema Group, Evgenia Emets.



Fig 7: Khaos – Analema Group – performed by Evgenia Emets, 2012

Gaelle Berton's "Dream Dust" was the first ever art piece showcasing real time motion capture as telepresence art on a holographic screen. Berton's art persistently pushes the boundaries of the technically feasible and combines a sense of techno-avantgarde with poetic and tightly choreographed performance. "Dream Dust" features a live musician, whose dreamlike visions are brought to life as a point cloud surrounding him. This abstracted form of "Dream Dust" is brought to life by a secondary performer who interacts with the scene via a remote relay interface, her life-sized silhouette pushing in and out of the performer in real-time. Gaelle Berton piece introduced both motion tracking and telepresence to the context of a holographic art. Pioneering cinematographic forms and performative expressions, Laura Jean Healey's "The Siren" was the first underwater, slow-motion holographic projection piece in the history of Pepper's ghost: The Siren subverts ideas of the gaze, poses questions of seduction, power and transgresses the boundaries of cinematic narration. In the artists' words:

“The film explores of the nature of the feminine mystique within the screen and the seemingly active gaze of the audience, to reveal the inherent paradoxes and enchanting nature of the seduction of the projected image.”

The poetic nature of the piece earned the artist national and international acclaim. The Siren plays on the notion of reciprocity of gaze, etherealness and fleetingness of the moment. The idea of seduction holds a strong statement on the fragile nature of the medium itself, its double role as canvas and a performative medium. The Grand Award of the MAMAs 2012 was attributed to New Opera Hero for creating holographic audiovisual scenery through voice and breath. Using paper-windmills as trigger, animated cityscapes emerged around the performers, created through human breath in real-time. Following on the success of the MAMAs, Musion Academy's work was displayed internationally at the Yota Space Festival in St. Petersburg, selected pieces went onto display at City of Dreams, Macau, London's now historic Shunt vaults, Manchester's The Lowry "DigiArt Festival" as well as Kinetica Art Fair or The Economist's Frontiers of Technology gala. As hub for artistic production, discourse and exchange the Musion Academy built a forum for those interested in holographic projection art, giving over 300 artists access to the technology. The MAMAs were unique in providing recognition for pioneering artists. Giving rise to a generation of artists, the Musion Academy provided a platform for an avant-garde of artists in holographic projection. Telepresence in the context of holographic displays enables new types of performance, engagement across a distance and a reconception of spatio-temporal parameters of communication: Telepresence is more than a mere technical condition. The composition of the term comprises the word tele- and presence, the idea of conjuring a remote presence experience. The terminology has been widely discussed in academic discourse, undergoing a discursive transformation that cannot be understood without its technological history:

1.4 History of Telepresence

As a cultural phenomenon, the technological origins of telepresence precede academic and terminological discussion. Sound telepresence has its precursors in the telephone, invented by Alexander Graham Bell in the 1870s. Videoconferencing originated a century later, when in 1971, the British Post Office, later known as British Telecom, established a direct microwave link. The Contravision network connected the broadcast studios of Glasgow and London. These fixed lines were using a mix of broadcast and CCTV technology.

In the UK, Rediffusion, a cable and television company, linked Sunderland Borough Council Offices in a videoconferencing network using video telephone links over hard wire for monochrome camera signals (Loyd 2012, p.31). In the United States Texas Instruments established satellite video transmissions for business purposes from 1980 onwards.

In 1980, Marvin Minsky coined the term “telepresence” and soon after audiovideo real-time became a commercial reality: BTs Contravision grew into a pan-urban network - increasing outreach, bandwidth and ultimately signal quality. By 1983, BT’s video conferencing division Vistel was expanding these services to up to 2Mbs and other companies followed suit.

With the expansion of image quality and image transfer rates, big business started to see the potential in the new communication infrastructure. From the mid-1980s onwards, banking-led consortia on both sides of the Atlantic were testing the water for big telepresence investments – Citigroup in America and Barclay in the United Kingdom. The first transatlantic link was established at the Wembley Conference Centre in 1982. A second market sector, hotel groups, made use of the new technical possibilities in the 1980s: Intercontinental Hotel and US satellite operator Comsat General launched a system for eight to twelve people. Starting in 1982, the Hilton Group linked their NYC, Washington, Chicago and San Francisco premises for business applications.

From 1989, video conferencing reached the consumer market, turning telepresence into a desktop application. Picture phones were promoted by both Sony and Mitsubishi, but never really caught on with the masses. Dial-up services revolutionised video conferencing from 1990 as Internet links became more flexible. Launched in 1992, ISDN made telepresence more accessible, having being previously tested in the EVE-2 “European Videotelephony Experiments”. At the same time, the international and interdisciplinary research project, the “Ontario Telepresence Research” started to investigate telepresence and its effects on the public not only technically, but also culturally. On an artistic level, Roy Ascott’s “la Plissure du Texte” (1983) opened a new chapter in telepresence art. The artist Eduardo Kac was among the first artists to present telepresence projects. Having experimented with telepresence since 1986, his art installation “Ornitorrinco” was presented at Siggraph in 1992. Kac hereby established a direct link between Chicago and Siggraph Art Fair. The project was later expanded into a long distance installation from Austria to Chicago. Paul Sermon experimented with telematics installations from 1990. The pieces “The Globe Show” and “Earth Signals” and “Telematic Dreaming” are widely recognised as being among the first pieces of telematic art.

In the 1990s telepresence conquered new arenas of public life across the globe: HMS Prison Services adopted PictureTel’s technology for six difference telepresence sites across the UK in the early Nineties (Loyd 2012, p.33). As telepresence succeeded on a cultural, artistic and commercial level, new players entered the market: Sony, PictureTel, BT, CPT, Tandberg, Philips, Aethra, Dornier, SEL, Vcon dominated market offerings,.

Soon, multinationals such as Intel, Nokia and Microsoft showed interest in promising revenue streams. By 1998 this list was joined by Panasonic, Polyspan (soon to be known as Polycom) and Vtel. Artists such as Tina Keane ("Couch", Keane 1996), Ken Goldberg ("Telegarden", Goldberg 1996) or Sommerer and Mignonneau ("Interactive Plant Growing" Sommerer & Mignonneau 1993) continued to explore telepresence as well as their cultural implications throughout the 1990s. With Ars Electronica, telematic art had an international arena. The ZKM Karlsruhe opened its doors in 1989 as a museum of international significance with a specific focus on electronic arts, with telepresence as one of the key areas of interest.

Around the millennium, telepresence system codecs became increasingly inter-operational, as big players cooperated or merged altogether. Big acquisitions characterised the millennium: Tandberg bought CBCI Telecom, CLi merged with VTEL, Polycom incorporated 3M's AMS system and bought Accord Networks, before finally taking over PictureTel in 2002. At the same time Radvision and Tandberg moved closer together. Cisco partnered with face2face and ultimately Cisco and Tandberg jointly developed IP based systems. On a technical level, IP replaced ISDN progressively from 2001, while h.264 became the de facto standard after both Polycom and Tandberg committed to it. The second technical change of the millennium was the transformation from standard definition to high definition streaming. This shift helped the industry into a new era of prosperity, with worldwide revenue streams climbing to \$1.2 billion US Dollars in 2007 and to \$1.7 billion US Dollars in 2011 (See: Waynhouse Research In: Loyd 2012, p.33). On a corporate level, mergers continued to shape the industry. Cisco bought Tandberg in 2009, Polycom acquired ViVu in 2011 and Skype was sold to Microsoft. With Skype, a desktop version of telepresence had finally reached the mass market. Skype counted more than 660million users in 2011.

Consolidation in the telepresence market had various effects on the industry: Codecs and codec formats became inter-operational, products more comparable and the market as a whole more transparent. Equally, technical underpinnings became easier to compare and to evaluate. With the increase of bandwidth, video signal transmission is constantly improving. Standards of 6-8mbs upload and download are almost the norm for high end point to point communication. Photorealistic, life sized telepresence has been tested and probed on Pepper's ghost displays using a variety of networks and codecs. Specific formats were developed or at least adapted to optimize convincing realism on Pepper's ghost displays. Telepresence is becoming a reality in household and businesses worldwide. With this trend, the objective to improve the effect on individuals' perception becomes all the more relevant. Before discussing methods and strategies to improve telepresence perception, I want to introduce the history of academic discourse on presence.



Fig. 8: "Telematic Dreaming" (1992), Courtesy of Paul Sermon

2. Theoretical Context: Interactive Art – Frontiers of a Genre

The Oxford Dictionary defines interactive as allowing a two-way flow of information between a computer and a computer-user, i.e. as responding to a user's input (Oxford Dictionary 2015). A computer is defined not only as an electronic device, but as a person who performs calculations, especially with a calculating machine. It is this second definition of computing that needs to be engaged, when looking for an expanded conception of interactive art that includes art production before the 1960s. In the strict sense of the term, interactive art is linked to the history of computers as an electronic device. Capable of receiving information (data) and performing a sequence of operations in accordance with a set of procedural instructions (program), interactive art produces a result in the form of information or signals (Oxford Dictionary 2015).

Although both words "art" and "technology" etymologically derive from the word *techne*, sharing Greek, epistemological roots, interactive art does not primarily focus on technical explorations alone. In interactive arts, technology exists only as a tool to explore new realities, new forms of engagement and new expressions of meaning. Wong, Jung and Yoon from Seoul's Soongsil University argue that it is not sufficient for an interactive art piece to react based on the spectator's selection, but the meaning behind the interaction needs to be discovered (Wong, Jung, Yoon 2009, p.180). As Maria Teresa Cruz declared - "*Interactivity is not a specifically technological issue* (Cruz 2009, p.2)." Interactivity is thus not related to a technological mediation, it describes the process of engagement, the relationship between the spectator, the art piece and the artist.

The artist Nathaniel Stern states that in interactive art “installations are not objects to be perceived, but relations to be performed” (Stern 2011, p. 233) Interactive art is often understood as a subgenre of installation art, yet audience participation and real-time engagement are its integral components. Interactive art derived from performance art, happenings and the explorations of Fluxus. In between sculpture and installation, performance and participation, technology and tradition – interactive art is considered platform-independent and hybrid, bridging many conceptual rifts. Edmonds and Mueller assert that interactive art privileges experience over static objects” (Edmonds, Bilda & Muller 2006, p.142). As conceptual credo, this observation echoes Nicholas Bourriaud’s political account “that art is at once the object and subject of an ethic - art is a state of encounter” (Bourriaud 2001, p.18). While Bourriaud’s umbrella term of “Relational Aesthetics” conscribes social contexts and social engagements, interactive art is a dialogue in itself – a social encounter per se. According to Veronika Korakidou and Dimitris Charitos, in interactive art, “the visitor is the one that completes the artwork. Without him/her, the artwork does not exist” (Korakidou & Charitos 2011, p.281).

William Geoffrey Keays at the MIT points out that interactive art is as old as the cave paintings of Lascaux, which date back to 13000BC. Different painters collectively engraved narrative scenes into the caves, that served the purpose of a first light show: Torches were used to light up one scene after the other. Marks of spears on the cave’s walls indicate the audience’s immediate reaction to the spectacle. Ipso facto, the history of interactive art is not merely a history of technical advances (Keays 1999). The genres annals rather comprise a history of audience participation, physical engagement and changing participatory authorship. Interactive art does not always involve high tech gadgetry or the use of groundbreaking technology. Marcel Duchamps “Bicycle Wheel” (1951) transformed a bike wheel into a kinetic art piece. When audience members’ physical interaction created a readymade out of a single wheel, they also altered its visual effect through interaction. The way we experience interactivity in the arts changed dramatically throughout art history. Technical advances and innovation influence the way artists tackle inseminations of interactivity in artistic practice.

In “Interaction, Participation, Networking”, Peter Weibel (1990) explores the terms interactivity/interaction in the context of art history. Definitions of terminology appear vague and fluid if studied over time, as concepts and practices underwent multiple transformations across the decades. From Nam June Paik or Robert Rauschenberg’s Fluxus pieces of the Fifties, to Gene Youngblood’s immersive “*Expanded Cinema*” experiments of the Sixties, to Dan Graham, Valie Export or Peter Campus’ video pieces of the Seventies, to Christa Sommerer and Laurent Mignonneau, Jeffrey Shaw or Lynn Herschman-Leeson, in the 1980s and 1990s to current interactive art practices – spectators’ roles shifted with technical possibilities and altered conceptions of mediation.



Fig. 9 Lynn Hershman-Leeson, *Seduction* 1986

Interactive art engages the user in a two-way flow of information so that the artwork is significantly altered through his or her actions. The artwork wouldn't exist without the spectators' input. As Christiane Paul (2004) concluded, interactive art is not a recent phenomenon, as all art inherently strives to be interactive. Credited as one of the first major exhibitions worldwide to feature computerised interactive art, Jasia Reichardt's seminal "Cybernetic Serendipity" at the Institute of Contemporary Art set the tone for its academic discussion: In 1968, 143 contributors blurred the lines between science and art. 43 of these artists were composers and 87 were non-artists: engineers, doctors, scientists and technologists. Interactive art is deeply rooted, but not restricted to a wider discourse on art and technology.

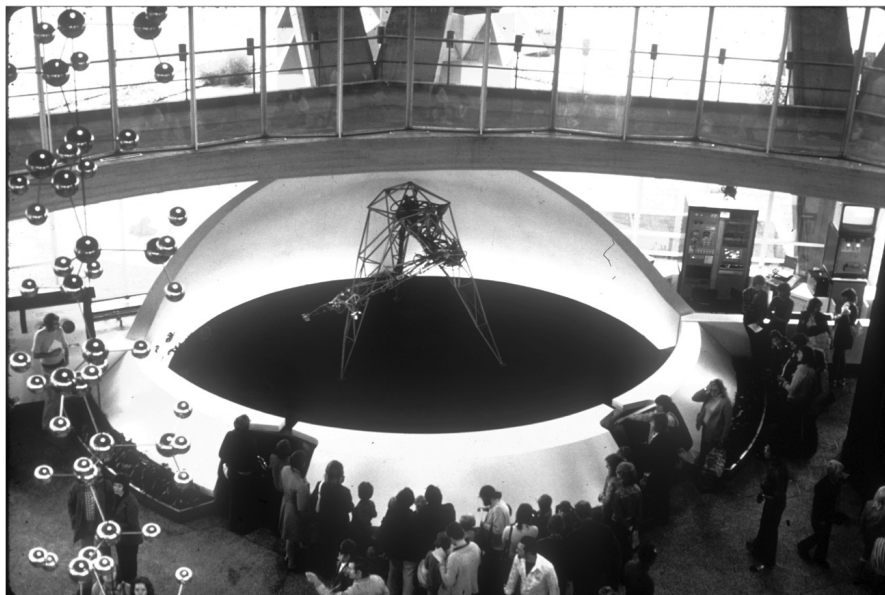


Fig.10: Edward Ihnatowicz: *Senster* 1968

The ICA – Institute of Contemporary Arts London - set a milestone in the contemporary history of interactive arts: In 2008 its artistic director Ekow Eshun decided to close the institution's "Live and Media Department" – a locus operandi hitherto dedicated to performative and interactive art. Eshun and the ICA reasoned that it was impossible to artificially segregate these art forms from other genres any longer: interactive art is everywhere. Between technology, installation and performance, artist happening and audience participation, the very essence of interactive art is to evade genres and classifications. Generative Art –an art that is closely associated with discourses on artificial intelligence, cellular automata and technical autonomy- is a neighbouring discipline of equally fuzzy conceptual boundaries. Dedicated museum spaces such as the ZKM in Germany, FACT Liverpool in the UK, Gaité Lyrique in France, or the ArsElectronicaCenter in Austria- are committed to the field of art and technology, digital art and interactive art. This institutional discourse focuses on both debates, generative art and interactive art side by side, yet as clearly demarcated theoretical constructs.

2.1. Generative Art – Computational Process and Autonomous System

In "What is Generative Art" Philip Galanter defines the term as "any art practice where the artist uses a system, such as a set of natural language rules, a computer program, a machine, or other procedural invention, which is set into motion with some degree of autonomy contributing to or resulting in a completed work of art" (Galanter 2003, p. 4). This broad and open definition reflects an inclusive approach, restricting the field to the use of autonomous systems in artistic production. Generative art is a rule based art form, closely linked to the fields of complexity theory and artificial intelligence. Outside the context of art theory, various definitions of autonomy exist: The Oxford Dictionary ties the concept to a philosophical or political background, by linking the term to the notion of freedom of choice. Autonomy is either understood politically as "the freedom for a country, a region or an organization to govern itself independently" or in a philosophical context as "the ability to act and make decisions without being controlled by anyone else giving individuals greater autonomy in their own lives." Yet none of these definitions have had any repercussions in the discussion of generative arts. Prevailing definitions centre around a terminology borrowed from artificial intelligence (see: Galanter 2003, McCormack 2001, Edmonds 2009).

In artificial intelligence and robotics, the term "autonomy" has played a crucial role in refining both control and intelligence. From the outset, artificial intelligence served as a conceptual backdrop for generative arts, whether on a theoretical level or in computational practice. The European Space Agency's definition of autonomy is strictly constrained to a set of conditions to be met by a robotic system. Both the term autonomy

itself and definitions for its subsidiary -“degrees of autonomy”- are thus technically restrictive and exclusive: Only when all of the six conditions are met and “performed without human guidance” a robot can be called “*autonomous*”. This definition clearly earmarks autonomy as a concept defined through the exclusion of human interaction. Autonomy is understood as self-reliance of a learning system. Self-subsistence and self-sustainability of growth, artificial intelligence and any corollary progress-based results explicitly excludes human interference.

In “Autonomous Robots: From Biological Inspiration to Implementation and Control” George Bekey (2005) refers to autonomy as “a system being capable of operating in the real world environment without any external control for extended period of time”. The very definition of autonomy in AI and Robotics is based on the idea of circumvention of human intervention. On the contrary, definitions of interactive art tend to focus entirely on human intervention, on active human participation in the creation of a “completed work of art” (Elwell 2010). Despite their obvious differences, similarities in both art genres exist: Proximity to technological discourses, frequent use of computational practices, and a rule based approach that often evolves around questions of chaos and control. Both traditions have a long history, with a recent resurgence in artistic production and institutional prominence. Both traditions are now firmly linked, but not exclusively confined to contemporary digital art. Furthermore, both terminology conceptions frequently changed over the last decades.

Comparable to the history of interactive arts, the history of generative art is as old as mankind and not intrinsically linked to a discourse on technology. Philip Galanter points towards Christopher Henshilwood’s discoveries of cave paintings of triangular shapes – 70,000 years old (Galanter 2003). Iterative symmetry and geometry have been an integral part of artistic creation from the Assyrian civilization to contemporary art production today. Yet it isn’t the inherent symmetry that makes these ancient art forms a subset of generative art. Generative art is neither representing a style, nor a technique. According to Galanter, “*in principle, any computer based generative method could be carried out by hand*” (Galanter 2003, p. 16). The terms “computer art” and “generative art” were used interchangeably in the 1960s, yet the use of computers is not a term defining variable. Henry’s “Drawing Machine” (Henry 1962) is considered to be more of a machine than a computer. Desmond Paul Henry is considered the first generative artist to exhibit in a solo show. John Whitney’s converted M-5 “Anti-Aircraft” had little resemblance with a personal computer, yet his piece is widely recognised as early example of generative art. As discussed, neither style nor techniques are defining characteristics per se. By definition, their main constituent is the prevalence of a rule-based system for the creation of autonomous artistic processes.

Early computer art was often perceived as congruent, if not equal to generative art: Georg Nees and Frieder Naacke are widely recognised as pioneers of computer art and generative art alike. Georg Nees and Frieder Naacke's seminal exhibition "Generative Computergraphik" in Stuttgart 1965 was the first of its kind – four years prior to Cybernetic Serendipity. Both artists used the term "generative" to describe artwork that was at least in parts automated and ultimately produced by a computer (Boden & Edmonds 2009, p. 23). Stephen Wilson or Ed Manning used computer-plotted lines to create generative art (Compare: Wilson 2002, Mannig 1975,). Other generative artists, such as Nicholas Schoeffler, Joseph Nechvatal or composers such as Cage used completely different means and techniques to the same end – to produce rule based art that is the result of automated procedures.

With the advent of software art, and the explosions of personal computers in homes of nuclear families, the terms computer art and generative art experienced a certain degree of differentiation if not delineation in its discussion. A series of conferences and a wealth of publications led to a refined distinction of terms. Philip Galanter's relatively young definition is preceded by decades of artistic production that saw revolutions in music (John Cage, Lejaren Hiller), installation art (Brian Eno, Sol LeWitt) and program-based art (Jon McCormack, Mark Napier). More recently generative art proponents transgressed borders of any subgenre (Marius Watz, Genetic Moo, Michael Takeo Magruder).

The theoretic framework of generative art is deeply rooted in artificial intelligence and cybernetics - both in practice (Roy Ascott) and theory (Gordon Pask: in Edmonds 2009). In robotics and artificial intelligence, the term "autonomy" conscribes a set of technical conditions for a given robotic system: Capable of interpretation of directives, such a system needs to be environment aware, self-controlling and able to anticipate outcomes of its own actions (see: European Space Agency ESA). In generative art, autonomy as a concept takes its terminological references and linguistic clues directly from Artificial Intelligence. Algorithms and rule sets are a fertile ground for generative art – art that operates in a system of self-subsistence no matter whether this is language (Sol LeWitt), physics (see: Wilson 2002), biological paintings (Joseph Nechvatal 2004) or architecture (Celestino Soddu 1989). Generative Art is subject to controllable directives, capable of self-control and predictable as it relies on a set of rules. Artistic creation often starts with a conscious choice in applying these rules, but isn't limited to any medium, topic, technique or philosophical context.

Questions of order and chaos are intrinsically linked to these rules and determine its philosophical proximity to complexity theory (Stephen Wolfram 1985). Generative art is either outcome or process of an artistic production based on autonomous systems - thus excluding human spectator agency. Interactive art, on the contrary, is based on spectatorship agency. Interactive art is per definition either the process or creative result of inter-subjective human art generation. At first, demarcation lines of both art forms seem clear-cut. At the heart of creation and discussion of both genres lies the same question on chaos and control: In interactive art and in generative art, controllability is reached through rules: In interactive art, the absence of rules defines human interaction. In generative art, rules create art. Yet the same artists, whose work leads to a discussion of terminology, continuously raise questions on authorship and visitor participation throughout their work – thereby challenging the concepts of the very genres they created.

2.2 Generative Art or Interactive Art?

In both generative art and interactive art, a broad academic consensus has cemented dominating meta-concepts. These terminologies are tied to inclusiveness of computer-agency, yet appear mutually exclusive in the role they attribute to human intervention. Artistic practice has always challenged academic debates. This pursuit of a critical role doesn't stop in the digital arts. Generative as well as interactive art practice deviate from their respective theoretical contexts. Their nature challenges our conception of computer-human interrelations. To the extent that we question where an autonomous computerised process starts and where it ends, where the radius of action for humans follows automated procedures, we find distinctions between humans and cyborgs (Donna Haraway 1990), human and posthuman (N. Katherine Hayles 1999) or if the new philosophies for new media (Mark B. Hansen 2004) are so new after all. By challenging existing definitions of digital art, artistic practice engages in theoretic meta-discourses on the relationship between humans and computers.

Exhibitions such as "Talk to Me" (MOMA 2011), Decode (V&A 2010-2011) or "Choreograph Me" (2010-2011) at the Hayward Gallery – focus on the role of the audience in the exploration of contemporary interactive art production. All three exhibitions set milestones in the curatorial discussion of their respective fields. All three exhibitions presented work that can be classified as either "Generative Art" or "Interactive Art", yet none of these shows draw a distinctive line between the two concepts. Both categories are mutually exclusive. As conceptual antagonisms, they ask for distinctive denotations for both genres. Yet these classifications don't seem to resonate in either art practice or the realities of their presentation.

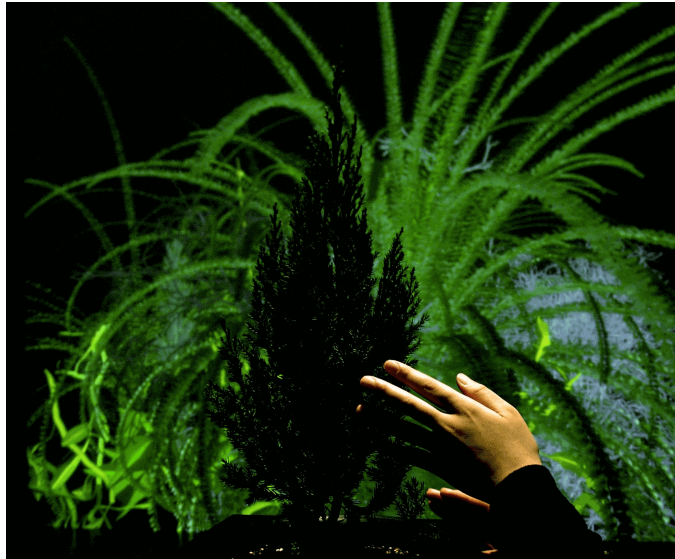


Fig.11: "Interactive Plant Growing", Sommerer & Mignonneau 1993

In Nicolas Myers piece "Transgenic Bestiaries" (Myers 2009), exhibited at MOMA's "Talk to Me", spectators created autonomous organisms of a new species out of an existing DNA stock. Mixing and matching, the spectator becomes the creator of a new life form - an artificial intelligence created out of DNA code. Is this a case of generative art or interactive art? Modified DNA code creates an autonomous system. Life forms that are self-sustainable and non-dependent on human interaction need human interaction to be initiated. Generative Art or Interactive Art – what are we looking at? In one of the now classic pieces of interactive art, "interactive plant growing" by Laurent Mignonneau and Christa Sommerer (1993), plants act as an audience interface to control the real time growth of artificial, generative, virtual plants. Plants become an interface for real-time controlled generative art, art that is generative and interactive – autonomous as a biomechanism, yet dependent on human interaction to become visible, to become alive. *Botanicus Interacticus* (Sommerer & Mignonneau 2012), presented at Siggraph echoes Sommerer and Mignonneau's seminal piece: Digital organisms are created through real life forms, human interaction triggers generative computer art as a mirror image of biodiversity, and biomechanics. Developed by Ivan Poupyrev from Disney Research, Pittsburgh and Philipp Schoessler, University of Arts Berlin, "interactive plant technology" (2012) displays plants acting as a transmitter of electrical currents. These currents are subsequently transformed into real-time generated digital organisms, visible only in a mirrored reflection behind their emitter. The visitor triggers the digital growth of these generative digital art forms through interaction with the live plant. Should we classify this as an interactive form of generative art or a generative display of interactive art? Pepper's ghost builds a new platform for both digital art and interactive art: As much as the boundaries between interactive art and digital art are fluid, transient and in motion, Pepper's ghost projection played host to a plethora of different art forms that escape any clear cut definition of medium or genre.

2.3.Holographic Projection Art as Sculpture

As a medium of optical illusions, a number of artists have engaged in a discourse on user perception, optical illusion or visual deception. Artists from fields as diverse as performance, narrative, dance or fashion explored the possibilities of this screen technology. As an artist with a specific interest in kinetic sculptures and perception, Madi Boyd displayed nationally and internationally. Institutions such as the Science Museum London or the Dublin Science Museum exhibited her work. Her interest in Musion was fuelled by the possibilities to engage audiences in new ways of seeing. Her piece “Space Time” (Boyd 2012) looks at time and space as a continuum that can be interrupted, interfered with and ultimately distorted. A dancer bends geometric lines projected into the open space, as if physically warping spacetime through movement.

Madi Boyd’s “MadInk (2008)” works as a fluid sculpture in which droplets of coloured ink slowly fill the entire field of view as a spatial holographic experience. The artist Michael Takeo Margruder created holographic sculptures that display a real time feed of news fuelled by the never-ending input of images from the worldwideweb. Using real-time news feeds as live input, his data flowers (Takeo-Margruder 2010) create ever-changing holographic sculptures that look incredibly organic. Louis Dijon holographic “Cake” 2006 comments on limitations of digital representation. Although the sculpture looks incredibly life-like, holographic representation lacks the ability to portray a sense of smell, let alone of taste. Birgitta Hosea’s holographic sculpture “White Lines” (2009) reveals the creation process in her holographic projection piece. Drawing white lines onto the artist, her outlines are revealed cumulatively as a performative sculpture. Holographic projection’s continuous image stream can be used for monumental, sculptural display.

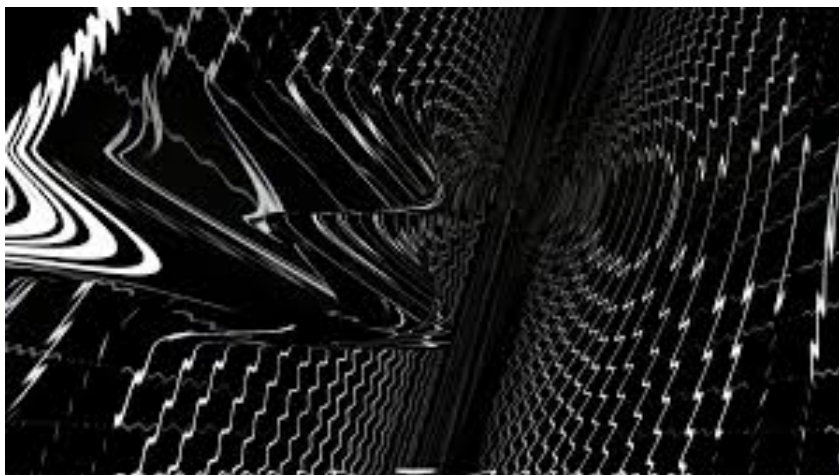


Fig.12: Space Time – Madi Boyd 2012

2.4 Holographic Projection Art as Performance

As a screen interface, holographic projection engenders different forms of stage interactivity, be it pre-recorded, live through real-time generated graphics or through streaming. The performance artist Rachel Garrard created a multitude of pieces using the Musion holographic screen as her canvas. In her first piece *Circuition*, awarded with the MAMAs Award for Performance art in 2009, the artist interacts with her own holographic alter egos, which multiply, disappear and reappear, ghostly and life-like at the same time. The performance artist Madaleine Trigg plays with suspension of disbelief in “*Sutre*” (Madaleine Trigg 2011). As her holographic dress disintegrates through the impregnation with water, the artist appears live inside her hologram as the projection disappears, leaving the audience wondering what is real and what isn't. Russian visual artist Kira Zhigalina (Ki-Ra) creates perpetual feedback loops on the holographic projection displays (“*Ephemeral Lightness of Being*”, Ki-Ra 2010) and through choreographed, interactive animation (“*Anima Mundi*”, Ki-Ra 2012).

Analema Group is a London based art collective consisting of artists, researchers and developers, founded by the artist Evgenia Emets with the combined role to explore new art forms through the integration of new technologies. Analema Group developed and performed a series of holographic projection art pieces. In “*Khaos*” (Analema Group 2011) the artist Evgenia Emets interacts with a fractal shape in real time through motion capture and real-time sound modulation. The art group “*New Opera Hero*” created an audiovisual spectacle that is part digital rock opera, 3D visual extravagance and takes its audience on a unique audiovisual journey. *New Opera Hero* coined the term “*automata*” to describe their practice. Automata are a hybrid art form, existing outside of classic art genres. On-stage 3D holographic projections are not only triggered through sounds, and motion graphics. In one iteration of their live show, stereoscopic graphics are triggered through human breath: The breeze of air on windmills creates holographic projections in an alternate reality. Live performance can assume a multitude of different forms on the holographic screen: real-time modulation, streaming or purely representational.



Fig. 13: New Opera Hero, Work Eat Sleep, The Lowry 2011

2.5 Holographic Projection Art as Narrative

The artist Laura Jean Healey is author of a number of Musion holograms, including her epocal signature piece 'The Siren' (Healey 2012). The Siren consists in an eerie and equally mesmerizing underwater performance in slow motion that plays on the subject of the gaze and the power of seduction. Laura Jean Healey creates narrative pieces that feel performative, immediate and push the boundaries of cinematic art. The Australian performance artist Stelarc created a "Second Life" performance, on the Musion stage. Audience members interact with the virtual space of an online gallery of the virtual environment in real time in the physical space of Kinetica Art Fair (Stelarc 2012). Online narratives and real-time performance blurred into a single event. The artist Simon Birch pioneered holographic projection art in a gallery context, in his collaboration with the artist Lucy McRae on the explorative installation "Crystallised" (Birch 2010). The Artforum described the piece as an evocative study on the fragility of the human body, "a holographic projection, which materializes via a series of mirrors and screens, shows an ethereal, half revealed figure, twitching as clumps of soap bubbles fall from her three-dimensional glistening skin." The artist Brendan Murphy created the piece "Not I" (Brendan Murphy 2008), a cross over between projection art and narrative. Taking its cue from Samuel Beckett's short play, "Not I" depicts a giant free-floating mouth, hovering in mid-air across the stage as a humanoid apparition.



Fig. 14: The Siren, Laura Jean Healey 2012

2.6 Holographic Projection as Telepresence Art

The artist Gaëlle Berton created the first motion capture triggered, holographic telepresence performance. *Dream Dust* (Gaëlle Berton 2012) is a real-time music video, via motion tracking, two dancers are translated into an abstracted point cloud particle stream, seamlessly diving in, out and through the musician on stage during his performance. Analema Group developed KIMA, a holographic telepresence performance on the effect of sound and immersion on presence. The piece will be presented as the first of three case studies in this paper and has been shown at festivals such as Kinetica, EVA London, the Festival of Learning Bournemouth and Siggraph. KIMA poses questions on the very nature of presence: Is it possible to evoke remote presence without visual representation? What is the role of sound in the contribution to telepresence? Is immersion intrinsically linked to presence? Holographic projection art, throughout its short history has played a crucial role in posing questions on the nature of virtual reality. What happens if the borders between the physically real and the virtual transcend? What if virtual realities become so convincing that the illusion of non-mediation creates a sense of presence indistinguishable from the real world? This research presents three case studies along with three key areas of presence research, exemplifying presence in the context of Pepper's ghost.

Over the last decade, holographic projection art has been displayed at Art Fairs (Kinetica Art Fair, Cecile Evans at Frieze Art Fair), at art festivals such as Yota Digital Art St Petersburg, DigiArt Manchester or onedotzero London – and in galleries. Formerly dismissed as hocus-pocus and visual sensationalism, holographic projection art has become a catalyst for artists working on the intersection of diverse genres, creating hybrid art forms that defy classic categorizations. Whether this is performative, cinematic art (Laura Jean Healey, Rachel Garrard), generative, interactive art (Analema Group) or audio visual art - holographic projection merges the fields of stage and screen, of sound and vision, of performance and installation. As an interface, as intersection, a new medium in a time of post media discourses – holographic projection art has a role to play in the wider discourse of contemporary art production. As an interface that crosses borders between sculptural and performative, different technologies and different art forms, Pepper's ghost gained an art theoretic relevance, occupying a unique position as platform for hybrid art practices. This research presents and discusses three different strategies exemplifying this relevance in the context of remote presence.

3) Literature Review - Terms and Definitions

Since Marvin Minsky coined the term telepresence in 1980, the neologism experienced a multitude of transformations. Its emphasis changed from a purely mechanical, robotic conception, into a terminology of virtual reality - ultimately becoming a function of everyday life. The history of telepresence is shaped by the people who performed, and developed and generated it. Marvin Minsky's pioneering, homonymous article "on telepresence", paved the way for practical, theoretical and artistic engagements. Hand in hand with technical innovations, artists such as Roy Ascott, Paul Sermon, Julian Freud or Tina Keane showcased telepresence art throughout the 1980s and 1990s - posing questions on remote physicality, dislocated production processes and the perception of presence.

Paul Sermon's piece "Telematic Dreaming" premiered in 1992 – together with "Telematic Vision" (1993) and "Telematics Séance" (1993). Together, they build a dense body of work that concentrates on creation of human communication and intimacy across a distance. Since the mid-Nineteenies, Pauline Oliveros shaped the history of telepresence art at the "Deep Listening Institute". Eduardo Kac's pioneered telematic art and new modes of visitor interactions in pieces such as "Genesis", 1999 and "Time Capsule", 1997. Artistic telepresence explorations went hand in hand with commercial developments: Desktop applications such as Skype, having introduced telepresence to households worldwide, resulted in the purchase by Microsoft for USD \$ 8.7 billion in 2011 (Lloyd 2012, p.34).

Telepresence consists in more than mere audio-visual conferencing – it describes the conveyance of presence in remote locations. New forms of telepresence present us with life-sized, photorealistic representations of perceived 3-dimensional images. Display technologies such as Pepper's ghost, stereoscopic screens or Oculus Rift allow to stream images of unknown realism between two or many locations. Telepresence based on Pepper's ghost (PG) was introduced to world markets in 2008. This form of 'holographic' telepresence engenders spatial perception, fluidity of image transfer and perceived photorealism. Based on a Victorian stage illusion, present-day PG systems use a specifically developed screen material, a bespoke lighting solution, state of the art high resolution, high-luminance projection and dedicated filming strategies to achieve effects of perceived on-stage real-time communication. PG telepresence shares with other media the concept of presence itself as well as key underpinning factors that will be presented over the next chapters.

3.1 Pioneering Conceptions - TelePresence, Telerobotics and Tele-operators

Before starting the discussion on the characteristics of Pepper's ghost (PG) based telepresence, the terminology itself requires examination. The history of the term and its academic discourse is as diverse as its practical applications. Definitions of the term vary drastically from field to field according to academic context, technological focus and researcher's bias. Credited with the creation of the neologism "telepresence", MIT's Marvin Minsky first presented the concept as a sense of "being there," (Minsky 1980), and a "sensation of reality." In his seminal article "On Telepresence", Marvin Minsky's point of departure is interactivity, remote controlled tele-operations in areas as diverse as engineering, medicine, space programs, nuclear power and other high-risk scenarios. "Telepresence emphasises the importance of high-quality sensory feedback and suggests future instruments that will feel and work so much like our own hands that we won't notice any significant difference." (Minsky 1980, p.43) In this early academic discourse, contextualisation of the term were primarily linked to computer interfaces, robotics and remote cybernetics. Direct control over long distances and the idea of man-machine interfaces dominated the academic discourse throughout the 1980s. Minsky's concentration on a technical conception was echoed by his field: Atkins refers to telepresence as "achieved by projecting the operator's manipulatory dexterity to a remote environment while reflecting sensory feedback so realistically that the operator feels present in the remote site" (Atkins et al. 1983). For Sheridan "a more restrictive definition of telepresence requires further that the teleoperator's dexterity match that of the bare-handed operator" (Sheridan 1992, p. 6).

To this day, terminological conceptions in presence research depend largely on the discipline, varying significantly from their respective field of study. Peer and Buss (Peer & Buss 2012, p.463) understand telepresence or tele-action systems as configurations "where a human operator controls a remotely located teleoperator, in most cases a robot, by means of a human-system interface so that the operator is not in direct contact with the environment, but interacts with it by means of a technical system". Peer and Buss stand in a technical tradition of engineering. Their view reflects their background as well as analytical agenda. Peer & Buss' conception is a recent example within a longstanding tradition of a technical comprehension of the term. A definition focusing exclusively on a robotic, haptic, physical dimension proved practically limiting: While early discourse on telepresence centred on a physical, technical conception, this narrow reading was perceived inconclusive in other fields. A newly emerging, parallel discourse concentrated on telepresence as communication strategy between human and computer.

3.2 Pre-millennium discourse: Remote Presence and Virtuality

Thomas Sheridan (Sheridan 1992, 1994) provided a definition that describes the effect people experience when interacting with a computer-mediated or computer generated environment. Sheridan defined telepresence as “the experience of being there” In his research, Sheridan focuses primarily on computer mediation for remote communication. According to Sheridan (1992) telepresence “means that the operator receives sufficient information about the teleoperator and the task environment displayed in a sufficiently natural way, that the operator feels physically present at the remote site” (Sheridan 1992, p.6). The idea of a perceived physicality of interaction, computer and teleoperator mediation, and perceived naturality of the presentation are key to his definition. Furthermore, Sheridan states, that “telepresence is sometimes used to describe virtual presence.” (Sheridan 1992, p.6) For Sheridan, the terms telepresence and virtual presence are interchangeable. Sheridan’s focus on computers as mediators remained important throughout the 1990s. Barfield and Furness extended that definition to to a “virtual environment or virtual reality or artificial reality the phenomenon that is experienced by a person when sensory information is generated only by and within a computer compelling a feeling of being present in an environment other than the one the person is actually in.” (Barfield & Furness 1995, p.481)

Thomas Sheridan’s influence on conceptions of telepresence continues to be relevant in the field of media communication. Sheridan implies a degree of computer agency - of human to computer interactivity - while shifting the focus onto user reception stimulus. Sheridan’s definition is antagonistic to techno-centric paradigms following Minsky’s original position, which perceive telepresence as inherently linked to a physical displacement or a remote controlled performance. Such robotic and tactile conceptions emphasise a haptic, motoric, interactive angle. As a trend, a techno-centred, physical emphasis in the 1980s was followed by a more anthropological focus in academic debate in the 1990s. Sheridan’s conception centres on the perceptive sensation of the user – shifting the focus away from a physical, manual interaction between man and machine into the realm of the user experience: In this context, telepresence is interpreted as a substituted perceptual reality for the user. For Minsky et al. on the other hand, telepresence originally implied a form of physical interaction relying on computerised, robotic telematics.

A third, elemental current runs through this debate - the notion of dislocation. Rosenberg (1994), Chapin, Lacey and Leifer (1994) for instance concentrate on the physical displacement between operator and operand: “The ultimate goal of these efforts is to produce a transparent link from human to machine; a user interface through which information is passed so naturally between operator and environment that the user

achieves a complete sense of presence within the remote site." (Rosenberg 1994 In: Wilson 2002) Criticism of the focus on dis-location, physical replacement and/ or communicational transport is fuelled by the fact, that not all telepresence activity necessarily requires physical distance. Networked telepresence can be setup within the confinements of a single building or even a single room. Within this third focus in the definition, the discussion shifted more and more towards questions of personal experience of spatial or physical qualities. Chapin, Lacey, and Leifer (1994) describe telepresence as a phenomenon that "enables objects from a different place to feel as if they are actually present." A dominance in presence discourse on remote robotics in the 1980s shifted towards distance communication and computer mediation in the 1990s. Held and Durlach (1992) as well as Steuer (1992) understand telepresence as reference "to the sense of being in a mediated environment." By locating the user "inside" a media environment, the idea of immersion is implied in their definition. Another paradigm shift occurred in academic debate: Throughout the 1990s, ideas and discourses on virtual reality and the illusion of non-mediation became increasingly prominent.

3.3 Concepts of Mediation and Perceived Non-Mediation

1990s telepresence discourse was characterized by spatiality, dislocation and virtuality. In his article "Virtual Interface Environments", Fisher understands telepresence under a spatial bias as "enabling people to feel as if they are actually present in a different place or time. (Fisher 1991, p.433)." The importance of a spatial conception is not ubiquitous. Beau Lotto, Mel Slater for instance dismissed the inclusion of any physical conception of presence at a remote location. Accordingly, humans are no longer required to be physically present to create the illusion of presence.

"The end results of both telepresence and virtual reality are essentially the same, a human-computer interface which allows a user to take advantage of natural human abilities when interacting with an environment other than the direct surroundings." (Rosenberg 1996 In: Wilson 2002, p.527). For Lotto and Slater, presence refers to subjective responsiveness of and to environments. Their definition encompasses the successful substitution of real sensory data by virtual sensory data, creating a link between the tactile definitions that followed Minsky's traditional view with the ideas of subjective experience and personal perception. Lotto's approach makes telepresence measurable, which is important for the methodological and analytical discussion of the term. Crucially, the sense of "Being There", of remoteness and cybernetic modulation turns into a single aspect of a larger picture on sensory perception. This expands the concept to include a multitude of sensual experiences. Lotto, Sanchez-Vivez & Slater (2009) define presence as the propensity of people to respond to virtually generated, sensory data as if they were real.

Users who perceive a sense of telepresence focus on the virtual or mediated environment, i.e. the perceived illusion of reality, to the extent that their stimulus field is limited. Technical Immersion implies a sensory encapsulation into a virtual environment, while the physical environment is disregarded, blanked out, replaced. Biocca states that “human beings can create a perceptual illusion of being present and highly engaged in a mediated environment, while they are in reality physically present in another place” (Biocca 1997 In: Lee & Suh 2005). This definition combines a sense of physical remoteness with an idea of immersion and its technical mediation processes. In this third group of conceptions emerging throughout the Millenium, questions of visibility and mediation are as important as ideas of physical agency. Skadberg and Kimmel (2004) perceive telepresence as a media-induced experience. In an equally introspective conception, Luna Dolezal describes the phenomenon of presence through the process of technology-enabled mediation. In “The Remote Body: The Phenomenology of TelePresence and Re-Embodiment”, she states that “for presence to occur, the technological interface and the immediate surroundings must recede from the user’s awareness, enabling the transparency of the hardware to provide access to the remote environment. In this case, one does not feel as though he/she is just interacting with a technological medium that gives mediated access to a virtual or remote environment; rather, the user feels as though he/she is really there (Dolezal 2009, p.209).”

Even though mediation is the most significant factor in Dolezal's conception of the phenomenon, only the feeling of **non**-mediation invariably establishes presence. Such emphasis shifts the focus from telepresence as a technical condition towards a subjective user experience. Along the same lines, Sadowski & Stanney (2002) or Insko (2003) distinguish between subjective and objective presence measures. Shifting the focus from technology apparatus onto effectivity in user perception, the importance of mediation recedes behind the concept of perceived non-mediation of a technology. Presence experiences are maximised when the technology itself becomes secondary – allowing the user an unfiltered focus on the experience itself. Kim and Biocca (1997) refer to telepresence as “the feeling of being a part of the phenomenal environment created by a medium” such that “the user of the medium considers the items in the mediated environment as unmediated and reacts directly to the items as if they are physically present objects.” In their seminal article “At the heart of it all”, Lombard and Ditton (1997) discuss the term “presence” from various different perspectives, as a social phenomenon, means of communication, as immersive environment. Yet in all scenarios, their conclusions lead them back to a narrow and succinct definition of the term: “perceptual illusion of non-mediation. By “perceptual” Lombard and Ditton not only imply subjective, but a definition pertaining to the human sensory, cognitive, and affective apparatus. Under this premise, the illusion of non-mediation is an inclusive term, describing at once immersion, and reactivity. An “illusion of non-mediation” occurs when a person fails to

perceive or acknowledge the existence of a medium in his/her communication environment and responds as he/she would if the medium were not there.” In this definition, the process of mediation, the choice of medium, the type of operation and the actual effect become secondary. Lombard and Ditton extend and expand the concept of telepresence from mere mediation, to include the idea of illusion: The audience is deceived to believe that technological mediation never actually occurred, fooled into a perceived, direct, unhindered communication, ultimately leading to the illusion of presence.

Lombard and Ditton concentrate on six different aspects to the term: Presence as social richness, as realism, as transportation, as immersion, as social actor within a medium, and as medium as social actor. Immersion is understood as a condition, an integral component in the definition of telepresence. Both on a physical as much as on a psychological level, immersion is attested a role of presence-defining qualities: Encompassing all senses, presence extends to the feeling of being inside another reality – whether this sensation is experienced physical or just emotional., I will concentrate on the practical components of immersion and degrees of its measurability, both technical and perceptual. For Lombard and Ditton, immersion implies social physical and perceptual involvement – a receptive concept closely tied to interactivity and engagement.

As an inter-subjective phenomenon, telepresence is linked to the experience of social richness, a concept of perceived non-mediated interpersonal communication. Following Argyle and Dean’ social richness theory (1965), the two main components of social richness are intimacy and immediacy. Social cues such as body language, speech patterns, behavioural cues (laughter etc.) as well as body orientation are conducive to presence (see Chapter 9). Lombard and Ditton perceive media interaction as contributing factors of presence, either as a medium interacting with viewers (broadcast) or the viewer interacting with the medium (computer, gaming, chat avatars). Lombard & Ditton, Witter & Singer and many others consider realism a core component of presence. Potter refers to the semantic component of the "magic window" dimension of perceived reality (Potter 1988 In: Lombard & Ditton 1997). Under this second paradigm, realism is understood as a social phenomenon rather than just a sensory stimulus. This second momentum will become relevant in the next chapters. Thirdly, Lombard and Ditton embark on a discussion on realism as transportation – a communicational journey from A to B – i.e. the phenomenon of presence as dislocation. Lombard and Ditton developed a toolset, categories and clusters and factors of presence, thereby extrapolating its causes and effects. Causation and effectiveness are the key areas of interest of this thesis, with the aim to create measurable improvements of telepresence experiences.

3.4 ISPR – A Definition For Presence And Its Critique

The focus on a single user as agent and “locus operandi”, refined the concept of telepresence as a subjective and personal experience. In the discussion of the phenomenon, we need to acknowledge that not all users perceive interpret stimuli in the same way. Depending on cultural, educational, empiric or demographic background, media-literacy and experience, the medium itself is perceived differently by individual subjects.

As a neologism the term telepresence described methods for operations controlled at a distance. Telepresence encompassed remotely triggered physical or mechanical interactions between man and machine. This conception limited the focus on remote physical interaction. Rapid growth of the Internet, the increase of direct communication methods (handhelds, smart phones) and new distance communication applications (skype, viber et al) led to a shift from haptic and tactile to visual, from mechanic to multi-sensory, and from technical to subjective and communicational concepts. These conceptions encompassed communication channels of one -to-one, one-to-many or many-to-many and included human-to-machine, machine-to-machine, or human-to-human interactions.

Rather than reducing the concept to physical distance interactions or the notion of virtual relocation, a third approach evolved around conceptions of mediation through perceived non-mediation: This approach conceptualized telepresence as a cross-media, media-independent, multisensory phenomenon of remote communication. In all discussions, the quest for a distinctive set of characteristics and measurable indicators prevailed. However, only a few models presenting measurable dimensions of presence emerged. Over the next chapters, such components of presence are identified, analysed and measured as operational entities.

The International Society for Presence Research (ISPR) championed one of the most conclusive and universal definitions of presence. The international committee, consisting of academics from various fields, tried to consolidate varying viewpoints in the year 2000. The ISPR defined telepresence as “a psychological state or subjective perception in which even though part or all of an individual's current experience is generated by and/or filtered through human-made technology, part or all of the individual's perception fails to accurately acknowledge the role of the technology in the experience” (International Society for Presence Research 2000). At the centre of this broad definition lies the concept of the individual user's impression of non-mediation. The irrelevance of any technical aid engenders and facilitates a direct, unfiltered and immediate multi-sensory experience. As a formula, the ISPR definition establishes the concept of an illusion of

non-mediation, enabled by technology at the core of any subjective telepresence experience. Technology is hereby reduced to the role of a prosthetic, plays a secondary part, behind the domineering conceptual element of the individual's communicative experience.

What creates the "illusion" of non-mediation? How can we measure specific characteristics of this illusion? How can we improve constituting factors to enhance telepresence experiences across different media? What variables engender presence and its components? How can we measure perceptual gratifications for the individual?

Luciano Floridi's fundamental critique of this position concerns three key aspects (Floridi 2005): The difficulty of presenting presence as epistemic failure, i.e. as the illusion of, therefore as negation of mediation. Oxford based media philosopher Floridi attests that this double negation in the definition, entails that essentially we are faced with a case of mislead knowledge- into a false sense of presence. For Floridi, this Cartesian, subjective model lacks academic clarity. Not only is presence not clearly defined as either subjective or intersubjective experience. It excludes purely computer driven presence (virtual presence). And last but not least, it fails to account for its opposite: A definition as negation, as what presence is not (for instance a merely mediated environment) appears too vague, too erratic. Negating a negation, as is the case with the ISPR's dominant definition leads to an epistemic conundrum. Floridi points out that if part of the individual's perception is not failing to accurately acknowledge technology, then presence can still take place.

Various substantial criticism not only from a philosophical, ontological point of view, but moreover from an academic standpoint, has criticised the absence of standardised measurements to accurately compare presence experiences. As a perceptive, subjective experience, telepresence is difficult to compare through quantitative methods. This thesis presents a new theoretic perspective, a standardised classification system, which looks at presence as a synergetic phenomenon made up of a multitude of dimensions. Through the analysis of presence via its core components, I want to propose instruments for further analysis. Key factors of presence are investigated through mixed methods to allow for a convergence of data and a synthesis of my findings.

4. Theoretical Framework: Co-Factors of Presence

A research body of almost 30 years of analytical deconstructions of the phenomenon provides ample tools for accurate measurements of presence, evaluation instruments for accurate measurement. A multitude of classification systems of telepresence co-exist with various degrees of complexities: Lombard & Ditton presented one of the most systematic models of presence. Lombard and Ditton (1997) defined presence as construct consisting of a range of dynamic forces – including but not limited to social experience, realism, immersion and transportation. Studying different definitions, parallels, coherences and trends emerge. Discrepancies and inconsistencies between these models make a concentration on relevant key components necessary.

On a methodological level, classifications of telepresence were developed for sonic as well as visual telepresence: Renaud lists three distinctive cues for phonetic telepresence - behavioural, notational, and temporal cues (Renaud 2010). Witmer and Singer differentiate between four distinctive factors: Degree of control (immediacy, anticipation, mode of control), sensory factors (environmental richness, consistency of multimodal information), distraction (isolation, selective awareness), and realism (Witmer & Singer 1998, p.225–240). Sadowski and Stanney (2002) identify individual and system variables such as ease of interaction, user initiated control, pictorial realism, length of exposure, social factors and system factors. Sheridan identified five factors of telepresence – three technological and two context based factors (Sheridan 1992, p.120-126). Freeman favors a further reduction of discourse relevant components to at most three factors - spatial physical presence, immersion, and social realism (Freeman 2004, p.101–112).

Key consistencies emerged during the academic discussion of components across different models. In the presented model, recurring discursive factors of telepresence are narrowed down and identified as the three key factors that emerged throughout presence research debate: immersion, involvement, and realism. All three factors, have been widely discussed as key components of presence and will be presented one by one and scrutinized on their relevance, both in theory and practice: Immersion was specifically singled out by Barfield and Weghorst (Barfield & Weghorst 1993, p.699-704). Prothero and Hoffman (Prothero, Hoffmann, et al. 1998, p.393-400) and Hoffman, Prothero, Wells, and Groen. The latter also discussed the relevance of involvement and interactivity for the construction of presence (Prothero, Wells & Groen 1998, p.251-263). Barfield and Hendrix (1995), Freeman (2004) and Witmer & Singer (1998) among others focused on realism as core element of presence.

A strong argument for a simplified and coherent model for telepresence persists. Analyzing a complex phenomenon over elemental key dimensions provides the

fundament for a effective methodological approach. As a multi-sensory user-specific phenomenon, telepresence requires a conceptualization that ensures cross-platform compatibility, flexibility in application, and the possibility to be applied to both quantitative and qualitative research. Telepresence has long left the confinements of abstract, fictional academic discourse behind, to become a function of everyday life: people around the world engage in voice-over-Internet-protocol (VoIP) calls, videoconferencing, and Skype calls via handsets, tablets, laptops etc. As the use of telepresence gains momentum across the globe, the need to understand the concept of remote presence increases. With a new plurality of media, new models for cross-platform analysis are required – not only in the context of Pepper's ghost.

The presented classification system is user-centric, based on subjective perception of presence, and focuses on individual experiences within the analysis. The model is furthermore media unspecific, concentrating on core dimensions of presence that can be applied to a range of technologies. Depending on the choice of media, certain factors might be more or less conducive or detrimental to the overall perception of presence. 3D environments, 3D display technologies, augmented reality tools such as 'Oculus Rift' or Pepper's ghost mediate presence as much as networked streaming, mobile phones or tablets. Technical modalities and technical tools in use for telepresence remain secondary in dominating definitions of telepresence. Telepresence was defined by the International Society for Presence Research (ISPR) as "a psychological state or subjective perception in which, even though part or all of an individual's current experience is generated by and/or filtered through human-made technology, part or all of the individual's perception fails to accurately acknowledge the role of the technology in the experience" (ISPR 2000). Criticism of this definition points to its ontological shortcomings, the inability to measure presence according to this narrow conception and the inherent double negation, which makes any argumentum e contrario, any converse argument impossible (Floridi 2011).

The terms telepresence and presence have been used concurrently, with the prefix tele-stressing the technological component of the sensation. "An "illusion of non-mediation" occurs when a person fails to perceive or acknowledge the existence of a medium in his/her communication environment and responds as he/she would if the medium were not there." In this definition, the process of mediation the type of operation and the actual effect as well as the choice of medium become almost irrelevant. Presence is not seen as a function of traditional virtual environments, but is seen as a multi-dimensional, multi-sensory experience.

The focus on key properties of presence shifts the onus from the media itself, or from the idea of illusion onto the user and its perception. *Presence is an interactive remote communication experience with immersive qualities, resulting in the perception of realism.*

In conceptualizing immersion, realism, and interactivity as core factors of telepresence, the focus shifts to underlying factors, measurable components of presence, and their respective sub-components - audiovisual cues.

Realism is frequently understood as integral core-factor of presence. Image quality, transmission signal, lighting, resolution, image size, among other factors jointly affect the perception of a transmitted signal, its believability. Whether or not disbelief is suspended defines the extent to which presence of a remote person is acknowledged as actual, immediate, and realistic. Like immersion and interactivity, realism is a component of, but not a single requirement for presence. An abstract visual image can convey presence as much as a photorealistic video stream as will be shown over the course of this research. Realism, understood as fidelity to the physical world can be analyzed across multiple dimensions such as subjective/perceptual parameters as well as technical parameters.

As a bridge over time and space, presence can convey a sense of physical reality – without the need of physical representation. Within this conception, presence is closely linked to technical questions of realism and underlying factors: camera angles, lighting and technical considerations such as resolution and image quality contribute to a stronger subjective experience of presence (Bracken & Skalski 2009). An array of technical parameters contributes to realism, including image clarity, absence of motion blur et al. This research will provide an overview on existing studies on realism factors. As another core-factor of telepresence, immersion is understood as a perceptual/psychological reality and a technical condition alike. Immersion describes the subjective absorption into a mediated environment (Barfield & Weghorst 1993), separation from the physical world and perceptual predominance of a mediated reality. Immersion can be analysed across technical factors and subjective, perceptual parameters.

As third core-component of presence, interactivity is a construct with multiple dimensions. The Oxford English Dictionary defines interactivity as a two way flow of information between a computer and a user – allowing for the user's input (Oxford Dictionary 2015). Interactivity in the context of presence relates closely to social presence theory and rich media theory. Under this premise, presence is linked to immediacy and intimacy. Immediacy (latency, temporary effectiveness) and intimacy (closeness, emotional involvement) can be seen as parameters of interactivity. Steuer (1995) defines interactivity and vividness as key factors of presence. Questions of social behaviour, body language and direct speech are often quoted as underlying factors of interactive communication. Interactivity can be circumscribed as a technical condition or perceptual reality, a social condition and a state of involvement. As a co-factor of presence, interactivity is generated through both technical and perceptual cues. On a social level, interactivity is strongly related to concepts of intimacy and immediacy. As a technical

condition, interactivity has been analyzed across measurable dimensions control, time and directionality (Liu & Shrum 2002).

Presence has often been discussed under negative paradigms, focusing on accompanying artefacts – negative cues obstructing the audience's suspension of disbelief. Cha, Saddik et al. (2009) singled out negative key factors for presence perception in relation to stereoscopic head-mounted displays (HMDs). Mis-calibration of image disparity (Ferre, Cobos, Aracil, & Urán 2007), distance compression (Interrante, Ries & Anderson 2006; Messing, Durgin 2005; Thompson, Willemsen et al. 2005), inappropriate focus cues, inappropriate motion parallax (Livatino & Privitera 2006), spatial errors (Wann, Rushton, & Mon-Williams 1995), perceptual overloading of visual information (Alexander, Conradi, & Winkelholz 2003) represent notable artefacts. The discussion of negative, interfering factors of presence helps to identify parameters of cause and effect as well as positive cues. Vice versa, the focus on affirmative, contributive parameters of presence elucidates how we can measure and ultimately optimise presence experiences.

We can distinguish two broad categories of measurement methods: Malbos, Rapee and Kavakli (2012) differentiate between objective and subjective methods. Objective methods raise questions on validity of data, the potential of intrusions through measuring devices and accuracy of standards. Objective methods include heart rate analysis, behavioural analysis, brain wave analysis, eyetracking, galvanic methods, task demands, training efficiency (Sheridan 1992). Regenbrecht, Schubert & Friedman (1998) argue that the main problem with objective tests is the specificity of their results and their close interdependency with the virtual environment they are performed in.

As with objective methods, only few subjective methods yield valuable results independently of their immediate technical context – i.e. their virtual environment (VE). Witmer and Singer (1998), whose presence questionnaire (PQ) and immersive tendency questionnaire (ITQ) have become academic standards, argue that until the introduction of their own instruments only few systematic attempts to measure presence had been conducted: Notable achievements concentrated on factors of immersion (Barfield & Weghorst 1993), involvement (Hoffmann, Prothero, Wells and Groen 1998) and realism (Barfield & Hendrix 1995). Conceptions of these research instruments vary as much as the models of their interrelations. Subjective methods have been standardized to a certain degree. Slater's Sense of Presence Inventory test (SPI), along with Witmer and Singer's Presence Questionnaire (PQ) are well-established instruments, yet both tests have faced criticism for their accuracy and effectiveness. Slater deplores inadequacies in the measurement of presence contributing factors, as the coefficient implies a normalizing function, resulting in inconclusive measures. Witmer & Singer's test on the

other hand has been criticized for understanding immersion as a technical rather than perceptive condition. Despite this persisting criticism, Witmer & Singer's test has become a quasi-academic standard. Comparing tasks within and outside Virtual Environments, Usoh, Catena, Arman and Slater (2000) have shown that both tests show very little significance and are rather instable for cross-environment studies.

At the beginning of every analysis stands the exploration of its field, and its underlying concepts. These may vary as much as conceptions of the term itself. From the early nineties to the millennium, the discussion of presence was deeply rooted in a discourse on virtual reality and virtual environments. To the extent that virtual realities have become omnipresent, the importance of "virtual environments" as a physical setup for this discourse has diminished. Research instruments have been modeled as media-independent, reaching beyond the boundaries of a specific virtual environment. In order to measure the effect of presence, we need to understand underlying components – be it through objective or subjective research instruments - regardless of its medium. Definitions of presence factors remain heterogenous. There seems to be a need for a simplified model that allows for cross platform analysis, a consolidation of different approaches. Reconciling disparate positions, three core dimensions of presence emerged from domineering discourse stances. Although the majority of researchers focus either on technical aspects or on subjective and perceptive components, both dimensions are integral to the discussion of the phenomenon.

Differentiating between a set of subcomponents of presence, measurement instruments become more accountable and analytically effective. The proposed standard telepresence model is a user-focused classification system, putting the audience and their individual perceptual experience at the heart of the analysis. Virtuality is conceptualized as a component of interactivity. We are using digital environments, 3d display technologies and tools to mediate reality. However, the form and technical modality of these interactions is secondary. However, the concept of communication remains central to our understanding of presence. Going beyond factors of dislocation and mediated interaction, *presence is a multi-sensory interaction of perceived realism within an immersive environment*. All three elements of telepresence can be evaluated measured and analysed independently: subjective degrees of immersion, parameters of realism and degrees of interactivity for the user. In discussing three components of telepresence of this proposed standard model, their respective underlying audiovisual cues are presented. Applying this model to three case studies, the relevance for the relation to presence can be evaluated.

4.1 Co-factors of Presence: Interactivity

Academic discussion of interactivity has been characterised by a discursive dilemma: On the one hand side, a multitude of heterogeneous conceptions coexist, a lack of clear and precise definitions persists on the other. Shrum and Liu's (2002) multidimensional model of interactivity has widely been accepted across academic discourse as well as in market research practice. Here, interactivity is defined as the ability to communicate directly with one another, regardless of distance or time (Blattberg & Deighton 1991) or the extent to which users can participate in modifying the format and content of a mediated environment in real time (Steuer 1992 In: Liu & Shrum 2002, p.54). Liu and Shrum's model differentiates not only between human and human, as well as human and message interactivity, but classifies interactivity over three distinctive dimensions: *Active control* describes factors of user participation and stimulus. *Two-way communication* evolves around reciprocity of interactions and *synchronicity* discusses questions of time and immediacy.

Domineering academic discourse adopted this classification model, thus differentiating between functional/actual and perceived interactivity across those three dimensions (Kim et al. 2011). Discussions of functional interactivity describes the effectiveness of two-way communications or a system's responsiveness, the absence of latency and reciprocity of a system - measured as frequency of interaction. On the other hand, we distinguish subjective factors of perceived interactivity characterised by control, two-way dimensionality and time (McMillan & Hwang 2002, p.41-54). Perceived and functional interactivity are often congruent if not identical. The dialectic approach chosen by McMillan & Hwang contrasts technical and functional factors with perceived, subjective dimensions. Like two sides of a coin, the two sets of parameters congruently support and complement each other. This dialectic approach also informed the standard model proposed here.

McMillan and Hwang's classification system measures dimensions of interactivity by interrogating responsiveness and exchange of a medium; How does a specific medium engage with its audience? What is the possible frequency of engagement? On a secondary level, McMillan and Hwang measure user control as their degree of influence on said interaction; Last but not least, their model analyses time i.e. immediacy and delay as a component of interactivity. McMillan and Hwang concede that these dimensions overlap to a certain degree. Their classification system strongly focuses on online interactivity, yet describes the concept effectively across media platforms – by deconstructing the concept into measurable units. The authors see a stronger overlap between control and dimensions of interactivity, and a lesser degree of correlation for the factor time with the other two. Interactivity is thus predominantly measured through

variables of responsiveness (measured as frequency), control (measured as level of engagement) and to a lesser extent through latency and immediacy of interaction. Kim, Spielmann and McMillan (Kim et al. 2011) understand interactivity as a highly subjective concept depending largely on individual factors of media literacy and experience of perceived interactivity. In the context of presence, this subjective paradigm is relevant to the discussion of audience suspension of disbelief. The authors propose the use of an index - Measures of Perceived Interactivity (MPI) – based on the aforementioned three components of interactivity (compare: Shrum & Liu 2002). This model, firmly rooted in the world of online market research, contains valuable insights for our understanding of interactivity and its contribution to the evocation of presence.

Shrum & Liu's model provides a cross-media definition of interactivity that applies to presence research. All three elements of interactivity as categorised by Liu and Shrum play a part in audience perception of presence. "Active control" (AC) describes the audience propensity to interact - which can be influenced by their media literacy, their willingness to suspend disbelief or their activation level. "Dimensionality of communication" (DC) describes different levels of reciprocity – levels of senses addressed as well as frequency of interaction. Last but not least, "synchronicity" (S) describes questions of immediacy, delay/latency and time to respond. In the course of this research, all three aspects of interactivity will be discussed: "Active Control", "Dimensionality of Communication" and "Synchronicity". The media independent character of this categorisation, their measurability and usefulness in previous studies provides a tested and reliable framework for this research.

Interactivity is not only a technical condition, it is a perceptive reality, a potential of personal engagement and of the user's personal involvement. Interactivity is a co-factor for user's perception of remote presence - a perceptive condition (active control) facilitated through technological cues at a specific rate (dimensions of communication and temporal cues). Active control can be heightened through audio-visual cues such as fidelity of the image (Bracken & Skalski 2010), a sense of realism or the content on display. Equally, the concept of interactivity is related to questions of intimacy, immediacy and immersion (compare: Lombard and Ditton 1997): One set of factors of presence preconditions the other. Perceptual as well as technical cues jointly contribute to notions of presence. Cues for immersion and cues for interactivity are strongly interdependent - mutually influence each other. These individual factors are further influenced by the element of realism – again not a requisite, but an important component of presence. The relationship between these three components is discussed throughout three case studies. The aim is not only to investigate interrelations, but to probe the significance of the hypothesis of this thesis. The hypothesis postulates an intrinsic link between these components and the phenomenon of presence.

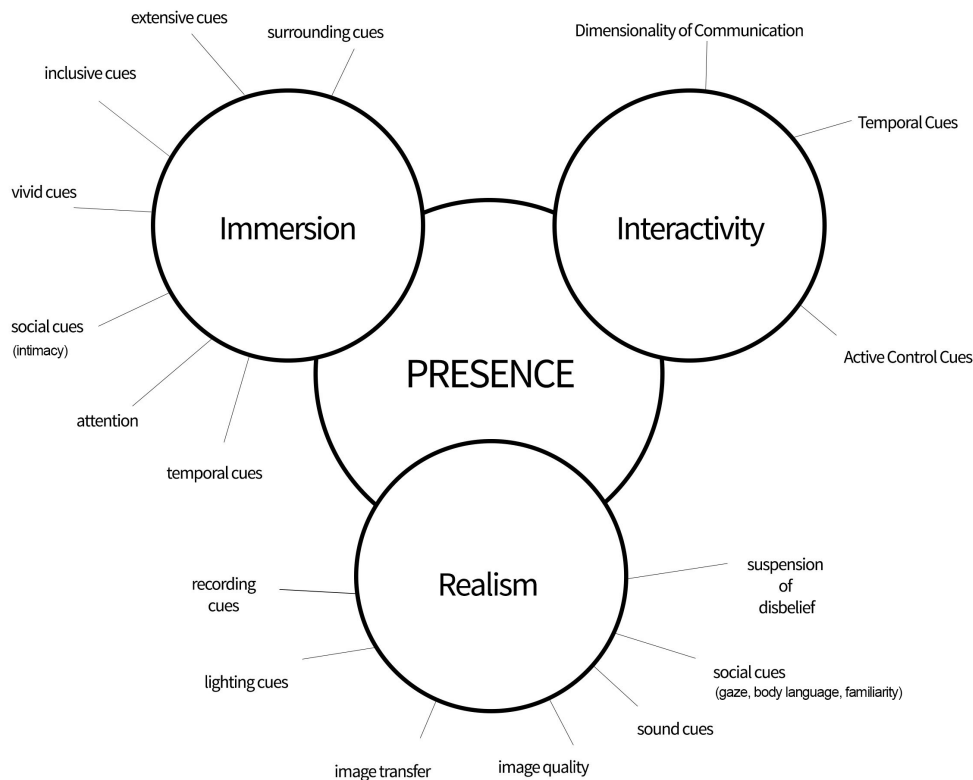


Fig. 15: Detailed Schematic - Standard Telepresence Model

4.2 Co-factors of Presence: Immersion

Oliver Grau describes immersion as an experience that hermetically, “almost wholly virtually seals off the observer from external visual impressions, appeal to him or her with plastic objects, expand perspectives of real space and illusion into space, observe scale and correspondence and like the panorama, use indirect light effects to make the image appear as the source of the real.” (Grau 2003, p.13) Biocca understands perceptual immersion as the degree “to which a virtual environment submerges the perceptual system of the user.” (Biocca 1992, p.25) Cinematic experiences and theatrical environments are often linked to immersion – as surroundings that are characterised by the hermetic occlusion of external influences. Visual artist Tony Dove states that in “an immersion environment subsists a flow of motion” (Dove 1994, p.283). According to Dove, the combination of exclusion of distractions and the focus on a complete alternate reality engaging the user in an all-absorbing flow, contributes to a different kind of presence.

Social immersion is understood as the degree to which audience members are mentally absorbed by a mediated reality. Immersion is a psychological state that implicates engagement and sensory audience apprehension. In an immersive experience, the viewer leaves the world behind to almost solemnly concentrate on the media environment and the sense of presence it engenders. Psychological immersion is best measured by surveys and audience interviews. To this end, Bracken and Skalski (2009) conducted Sample T-Tests on 50 undergraduate students to test the significance in the influence of image quality on perception of immersion and spatial presence. Recollection interviews provided Bracken and Skalski with a reliable evaluation process and combined quantitative results (recollection) with qualitative analysis instruments (interviews). Such a mix of methods ensures that subjective impressions can be paired up with hard facts - a strategy that informed the case studies presented in this thesis.

As a subjective perception, immersion is nourished through technical conditions (See: Slater & Wilbur 1995). Immersion is both a social and a technical condition. As a multi-sensory experience, immersion is nourished by conscious and subconscious, audio-visual and social cues. Immersion is an individual sensation of a near complete media engagement. According to Barfield, Hendrix and Bystrom (1997) immersion is solely generated by fidelity to the real world. Although immersion and realism seem to be interrelated, they are conceptualized as two separate idioms. The standard model presents immersion and realism as independent, yet inter-related co-factors of presence. Presence can occur in a purely abstracted form, as exemplified in this research.

As a bridge over time and space, presence can convey a sense of physical reality – without the requirement for physical proximity. Multiple studies have shown that immersion is statistically linked to this experience of presence (Bracken & Skalsky 2009) - this includes spatial as well as psychological perception. Slater (1999) along with Witmer and Singer (1998) defined presence as referring to experiencing the computer-generated environment rather than the actual physical locale. All too often, discussions of presence are limited by discussions of the virtual environment itself. Slater's understanding of the term "immersion" differs from Witmer and Singer's conception in that Slater's point of departure are the immersive qualities of the VE system itself, whereas Witmer and Singer concentrate on the immersive response of the users.

Slater and Wilbur (1995) look at immersion from a physical angle – quantifying its components through four co factors: Immersion can be inclusive (shielding external factors from the user), extensive (number of senses addressed), surrounding (encompassing the field of view), and vivid (resolution of displays). Schubert, Regenbrecht, and Friedman (2001) understand immersion as the sum of all hardware and software elements required to present stimuli to the user's senses. Through this definition, closer to Slater in describing the virtual environment than its impact, the authors aim to make immersion measurable by concentrating on technical conditions

such as fidelity of resolution, extractability of cues for 3-dimensionality. This model understands immersion as a technical event rather than a subjective condition.

Immersion is a complete perceptual experience, a multi-sensory ride. Image size, not to be confused with image resolution, plays a significant role in the creation of its effect –as do the engagements of other senses. Ideally all senses are equally addressed within an immersive experience. Immersion is both, a technical condition and a psychological state: Kim (1996) measures immersion through the number of senses that experience a mediated environment. Agarwal and Karahanna's concept of cognitive absorption (2000) looks at immersion across five different dimensions as a personal trait rather than a physical or perceptual condition - temporal dissociation, focused immersion, heightened enjoyment, control and curiosity. Cairns et al. (2006) measure immersion by looking at emotional involvement, perceptual/emotional transportation to a different place, attention, control and autonomy. At UCL, Cairns et al (2006) developed an immersion questionnaire for games, which relied strongly on these concepts. Their immersion score found a strong relationship between time spent in an immersive environment and perceived immersion.

Summarising, we can differentiate into physical, spatial or technical immersion components and perceptive, subjective and social immersion factors. Furthermore, we can analyse corollary technical and perceptual cues. This research model understands immersion as a perceptual condition mediated through a virtual environment encompassing as many senses as possible, through technical and perceptual cues. Technical cues have been defined, conceptualised and enumerated by Slater and Wilbur (1995) as inclusive cues (exclusion of the outer world, cognitive absorption), extensive cues (more than one sense addressed such as sound cues, olfactory cues etc.), surrounding cues (surround sound, 360 vision, 3D environments) and vivid cues (scale of display, resolution, colour space). Technical and perceptual cues are not mutually exclusive, complement each other and contribute to their overall impact. Technical, spatial and physical conditions are matched by perceptual cues such as social cues (social isolation, environmental dissociation), temporal cues (temporary dissociation, time consumption) and individual attention. All of these subjective cues can be measured, be it through questionnaires or through quantitative methods. Perceptual cues differ from audience to audience depending on cultural backgrounds, age etc. A person might be immersed into a game by giving it a lot of attention, but might not be socially secluded while engaging with the perceptive experience. Like technical cues, perceptual cues are not mutually exclusive, but cumulatively contribute to their overall impact. Both technical and perceptual cues - the fluidity of their concepts are characterized by a degree of flexibility and application across different media. These cues are conceptualised as constituents of immersion, not as requirements for presence. Through itemised cues, immersion components can be analysed, measured and evaluated.

4.3 Co-Factors of Presence: Realism

Realism is often linked to the conception of immersion. Realism, also understood as consistency between virtual world and physical world, relies on the complexity of sensory information. Schubert, Regenbrecht, and Friedman (2001) point out that realism can be, but is not necessarily a factor in presence: Totally abstract virtual environments can generate a high degree of presence without the need for realism. However, realism consistently has been quoted as a contributing factor of presence. This research looks at concepts and components of realism, its underlying parameters and aims to tackle some of the conundrums of this interrelation. All three case studies rely on abstracted forms of realism that ask for a wider definition of the term.

Realism encompasses the ideas of believability of a virtual environment, its integrity and audio-visual fidelity. The terminology encompasses the relationship between real-world and virtual environment, specifically similarity of depiction, convincing audiovisual representation and life-like, i.e. causally and logically consistent interaction possibilities. A multitude of technical variables concoct this simulacrum, the core of an illusion, a crucial element of presence. With Lombard and Ditton (1997), we can differentiate between key factors of realism, which can be subordinated into a technical and perceptive classification system: A first cluster of factors relates directly to the imitation of physical conditions and its spatial environment. This set of elementary factors describes audiovisual cues that refine a sensory similarity to the real world. This set of factors includes production and recording cues such as camera quality, perspective resemblance through accurate camera perspective and positioning (see: Lombard & Ditton 1997, Zettl 1990 *ibid.*), camera inherent qualities such as chip size, bit rate, frame rate, colour space as well as telepresence cues. Equally important is the absence of image capture artefacts (as discussed by Cha, Saddik et al. 2010), notably the absence of motion blur and focus blur.

A second cluster of parameters concerns adequate lighting, matching lighting conditions from recording to display environment, skin colours, brightness and exposure levels through lighting and lighting / display correlations. Image quality is not only defined by camera specific parameters, but also by signal transmission factors such as compression method, cables and connections, transfer rate and signal latency. All of these factors play a specific role in generating image quality – they constitute for the third cluster – codec and image transfer parameters. A variety of studies cement the influence that image resolution and image quality has on the notion of realism: Steuer (1995) cites vividness including sensory depth ("the resolution"). Bracken compared HD and SD signals and their effect on perceptions of presence in news broadcasting, establishing significant correlations between image quality and believability (Bracken 2006, p.723-741). Wood,

Griffiths, Chappell, & Davies (2004) and Shapiro, Pena-Herborn, & Hancock (2006) investigated image quality in respect of their effect on presence perception Lombard and Ditton (1997) as well as Short, Williams & Christie (1976) state that quality of sound emphasises the conveyance of presence. Image size and perceptive qualities of the image fall into this category (see: Ling et al. 2013).

Derived from Lombard & Ditton's model, we can distinguish between five main technical factors: Recording factors, lighting, signal transmission, image quality and sound cues. All these five technical cues can be contrasted with perceptual cues: Familiarity of the subject matter (Interrante et al. 2012) – i.e. is there a personal relationship between the subjects? Anthropomorphism – i.e. How “human-like” does the subject appear to be? Suspension of Disbelief – i.e. what is the propensity of the user to engage in the experience emotionally so to accept audio-visual cues? Cues for realism are strongly interrelated with immersion and interactivity factors. None of these components rely on each other, but they may influence each other directly or indirectly. Together the three co-factors of presence interactivity, immersion and realism cumulatively generate, evocate and induce the feeling of presence.

To probe the proposed model, a first test of realism research was conducted in March 2012. In this side-by-side comparison between two different telepresence systems between Musion head offices and Masergy's headquarters, different factors of presence and their relative effectivity were highlighted. Musion Eyeliner screen interfaces are very specific in their requirements to convey a sense of presence. Pepper's ghost displays require a multitude of factors to effectively present an illusion of multi-dimensionality. Dedicated lighting, sharp and colour spectrum rich imagery, and motion blur reduction all play a role in creating a realistic on-stage human interaction with a virtual image. This pilot case study compared different realism factors between two separate codec and lighting and camera solutions.

Table 1 Example of TelePresence Factors - Polycom Haivision Codec comparison – March 2012

Interactivity	Haivision	Polycom
Active Control	Room microphone	Handheld
Dimensionality	Comparable	Comparable
Synchronicity / Delay	similar latency	similar latency
Realism	Haivision	Polycom
Camera	Sony EX3	Polycom Camera
Perspective	Flexible	Fixed
Camera quality	1/2" chip	smaller chip size

Bit depth	10bit	8bit
Frame Rate	30i sharper	30p blurrier
Colour Space	422	411
Lighting	Holicom LED lighting	Polycom Lighting
lighting resemblance	daylight	Tungsten
lighting colour	better outlines	rich skin tones
lighting position	easy to setup, transportable	slicker permanent solution
lighting brightness	easier on dark clothes	difficult to pick up dark hair
Signal Transfer	Haivision Codec	Polycom Codec
Compression	less motion blur	more motion blur
Cables	VGA	HDSDI
Latency	Similar	similar
Transfer Rate	Similar	similar
Realism Display Quality	Musion	Musion
Image Resolution	Equal	Equal
Sound	Handheld	Room Microphone
Sound recording	best compromise	best experience
Sound display	similar	similar
Immersion	Haivision	Polycom
Screen Size	Musion screen	Musion screen
Subjective immersion	Heightened	Lower

Telepresence experts Charlie Day (Haivision) and Andre Ingram (Interactive Imagination), assessed differences in camera quality, lighting scenarios, compression standards, and image impact (see: *Table 1*). Direct comparison tests such as this one, confirm the importance for technical standards and their contribution to perceptual impact. Developing strategies for presence experience optimisations can engender significant improvements for audience impact and emotional engagement: Optimum telepresence experiences can only be achieved if production standards are maintained throughout the complete production process from recording, to image processing, compression to signal transfer and display. The role of sound throughout this process, specifically in the generation of immersive environments should not be overlooked.

Sonic forms of telepresence - bi-directional live streaming of communication- has its precursor in the telephone. Aural presence seems to experience less obstacles in creating a sense of reality than visual realism and is considered an important co-factor in the creation of physical presence altogether. Phonetic artefacts can present serious issues when creating a sense of presence. Yet research on the intrinsic link between sound and visual presence remains inconsistent. In the coming chapter, I will discuss a case study that highlights the notion of sound as a presence-generating factor. Lombard and Ditton (1997) as well as Short, Williams & Christie (1976) state that quality of sound emphasises the conveyance of presence. Equally, research by Kramer (1995) suggests that two key factors contribute to the emergence of presence - namely dimensionality and quality. Reeves, Detenber and Steuer (2008) found no difference in the perception of presence for surround and 2-dimensional sound. For the purpose of this study, we will compare two different setups: Setups using surround sound and setups using a 2-dimensional sound design so to be able to directly compare the two. It will be one of the purposes of this research to discuss the link between sound and visual telepresence and its effect on user.

Before presenting strategies for optimisation of realism, immersion and interactivity over three different case studies, all co-factors of presence require further analysis. Their discussion in the context of Pepper's ghost along with corollary, contributive cues points to a double nature of presence. Presence is not only a phenomenon of passive experience, but actively created, instilled, evoked phenomenon. Relying on a variety of perceptual and technical cues, such characteristics can be analysed across multiple dimensions. In Pepper's ghost presence experiences, the audience is key, as they are the main addressees of the illusion. The audience is the one perceiving presence, its unit of analysis. Consequently, throughout this analysis, the audience more than the interactant, is the main point of focus.

5. A Standard Model for Telepresence – an analytical framework

Presence is a multi-sensory, immersive experience through remote interaction within a realistic, life-like virtual environment. The telepresence industry strives to deliver unhindered interactivity through optimised intermediarity with little latency, a high degree of audience control and multi-dimensionality of interactions. Secondly, telepresence evokes a sense of immersion utilizing an array of technical factors, targeting as many perceptual senses as possible. Lastly, successful telepresence aims for a heightened degree of realism through a series of production factors, targeting emotional engagement through audience involvement. In our discussion of individual audio-visual cues, we apply this model across three dimensions to the example of PG-telepresence. The aim of this

research is to identify and test parameters that contribute to an optimised, immediate experience of telepresence on Pepper's ghost displays. Applying these factors to a virtual environment that integrates virtuality with reality highlights demarcation lines of this fluid concept. Abstract factors turn into concrete components - with specific relevance in the generation and optimisation of telepresence experiences.

Pepper's ghost can be seen as a virtual reality interface, enabling telepresence experience in real time within a real world environment. On a Pepper's ghost display, immersion is augmented through various different strategies: As an interface, Pepper's ghost is typically demonstrated in a specific lighting environment with controlled lighting conditions, at once excluding and integrating the outside world. Pepper's ghost excludes distracting exogenous factors such as unintentional light spill, reflections, all too bright backdrops, noise pollution, and can take the form of an almost cinematic, even theatrical setup. On the other hand, Pepper's ghost systems strive to dissolve boundaries between reality and virtuality, not only on display, but also within its technical confinements:

Users are confronted with on-stage real-time representation as a live, perceived three-dimensional image within their own environment. The more the separation between stage and screen is disbanded, the more the combination of screen dissolution, spatial projection and dedicated lighting cues creates an immersive ambience for the telepresence viewer. The larger the projection screen, the more the field of view is covered, the more intense the illusion. Increased screen size results in a higher degree of immersion, and ultimately in a larger degree of perceived presence (compare: Ling et al. 2013).

Immersion is not only a visual, but multisensory, not at least phonetic phenomenon. The KIMA case study presents immersion as component of presence, specifically focusing on immersive qualities of sound. As much as immersion has an impact on PG-telepresence, increased interactivity can augment experiences through a number of strategic decisions in the context of Pepper's ghost. Other than on conventional displays, interactivity on Pepper's ghost stages is perceived as a one-way illusion by an audience in front of a setup. The user on stage does not see the illusion. As a result, adequate facilitation of an interactive component is crucial:

The unhindered flow of communication through feedback signals and relay screens allows for optical illusions such as on stage interactivity between a live person and a virtual presenter, appearing as a 3-dimensional image to the audience. And not only scale and size of the relay screen, but latency of perceived image between signal

emission and signal-reception are key to seamless presence perception for spectators. The more multi-dimensional the interaction, the higher the degree of presence conveyed. Such technical factors -including latency and optimized codec solutions- are complemented by social factors: Familiarity of the subject matter (Meehan & Insko 2002), anthropomorphism (Mitchel 2011) and body language all play an important part in delivering the intended effect. Physical interactivity is a key factor not only for presence itself, but for audience engagement, as the “Transmission” case study will demonstrate in Chapter 8. Summarising, we can differentiate into three broad categories of interactivity. Following Shrum and Liu’s model (2003), these three factors can be applied to the specific context of Pepper’s ghost.

Last but not least, the effect of realism on presence can be crafted through an array of production factors, employed to create believability of a life-like representation on a Pepper’s ghost display. Realism is evoked through an array of different technical and perceptive cues, from recording, transmission to display parameters. It is the combination, triangulation and balance of these components that maximizes user impact. Realism is often understood as quality of representing a subject or object in a way that is accurate and true to life (Compare: Oxford Dictionary 2015). In this sense, realism refers to more than just visible facts, it extends to sound fidelity, spatial acuity, believability of relationships, ideas of cause and effects and other invisible parameters of reality such as heat, smell, or even brainwaves as this research will show. The third case study is dedicated, not only to a meta-analysis of realism factors in the context of PG-telepresence, but moreover to the subversion of the idea that realism is limited to visual representation.

In academic debate, objective and quantitative methods of measurement are contrasted with qualitative methods of evaluating presence – be it through questionnaires or interviews. Enumerating specific audiovisual cues of telepresence not only serves planning, preparing or generating maximized impact: Presence co-factors invariably build foundations to measure presence accurately. The context of Pepper’s ghost, presents an ideal framework for presence research, due to its capability of delivering life-sized, and realistic representations in a real-world environment. Pepper’s ghost, historically as well as in present day practice, is accompanied by dissolution of the screen, capitalizing on impact of realism, interactivity and immersion. The standard model helps to describe presence phenomena, to analyse and to evaluate the effect of specific presence co-factors.

5.1 Audiovisual cues for Immersion in PG telepresence

Following Slater and Wilbur's classification system (Slater & Wilbur 1995), we can differentiate between various forms of immersive cues, here discussed in the context of Pepper's ghost. This classification system will build the unit of analysis over the course of this research:

Inclusive cues: With Lomard and Ditton, we differentiate between a number of technical and social cues of immersion: Pepper's ghost traditionally uses a theatrical, almost cinematic setup to evoke immersion. Users are seated or standing, facing a stage within a controlled lighting environment. Similar to a cinema or theatre stage, PG-telepresence tends to be displayed within a boxed-off, darkened housing. Lighting cues augment 3d-depth perception behind the PG-image, The idea of creating an all-encompassing, sheltered projection environment can be summarized under the attribute "inclusive cues".

Extensive cues: In PG-environments, a number of cues attract the eye-line towards the back of the stage, ensuring that the user contextualizes the image. Establishing spatial awareness, the audience perceives the projection as located in and causally linked to the physical space around it, thus creating a perceptive link between projected imagery and the stage itself. This "extension" of the virtual image into the real world leads to a transgression of the virtual composition and an amalgamation with the physical world. This condition, further amplified by a multitude of additional factors, can be summarized as extensive cues. Other factors include the integration of virtual with real-world lighting, integration of setdesign into virtual imagery, dissolution between VE and audience area and many more. Such artificial assimilation augments the illusion of non-mediation of presence experiences.

Surrounding factors: A number of additional, surrounding factors help to immerse the viewer further: These include multidimensional sound or lighting cues from within the audience area such as dimmed ambient lighting, similarity in stage and proscenium areas. Collectively, integrated setdesign, surround sound, and ambient lighting can be categorized as surrounding cues. Immersive sound as a prime component of surrounding cues and ultimately immersion will be the focus of the first case study presented in the following chapter (Chapter 7).

Vivid cues: A number of additional technical cues ensure that the audio-visual experience is as life-like and as vivid as possible. These cues include the invisibility of the screen itself, a camouflaged, "hidden" projection method, high-spatial frequency and a

number of other factors: The invisibility of the polymer foil, which facilitates the disappearance of the screen in its set, is a key factor in assuring life-likeness of the illusion. In addition, the projection method, composed of luminance, resolution as well as image integrity (bit rate, codec, image quality) contribute to vividness of the image.

To summarise, we can differentiate between four categories of factors of technical cues collectively contributing to the generation of immersion of a virtual environment. These technical cues are further complemented by perceptual cues. The classification presented for technical cues within the standard telepresence model has been used by Slater & Wilbur (1995) as well as Lombard & Ditton (1995) and can be applied to the context of Pepper's ghost:

Inclusive cues: darkened room, controlled lighting

Extensive cues: visual depth through optical illusion of 3D, minimisation of sound and audio latency

Surrounding cues: surround sound, lighting environment encompassing audience area

Vivid cues: Disappearance of display medium (polymer foil), display size, high resolution display, high luminance display, high bit-rate

As discussed above, the concept of immersion extends to a social dimension, i.e. a perceptive experience. A virtual world is perceived as ever more immersive, if we are feeling emotionally, socially, personally addressed, involved and engaged. A subject will feel individually addressed, the more familiar he or she is with the subject matter - the higher the level of personal interest. As psychological factor, focus attentioned affects interaction. As Gorini et al. pointed out, experience of presence depends not only on feelings of immersion, but also on a sense of narrative and social engagement (Gorini et al. 2011). Perceptive cues are not restricted to emphatic, emotional or attentative attributes, but can include temporal cues such as a seamless entrance and good timing, little latency or the absence of awkward silences. These three factors, social predisposition and susceptibility or receptivity of the audience, and timing are interrelated and can be classified as perceptual factors.

Social cues: familiarity with subject can positively affect PG telepresence, intimacy and familiarity with the display environment

Attention: attention of audience members influences their behavior and receptivity of presence

Temporal Cues: controlled experience, defined beginning and end of streaming etc.

Above-mentioned factors are jointly conducive to experiences of immersion in telepresence environments. These cue factors are not mutually interdependent. Collectively however, they contribute to an augmented experience of PG-telepresence for audience members. All co-factors have been observed empirically, and can be tested directly and indirectly through questionnaires and interviews. The first of the three case studies specifically focuses on immersion in the context of Pepper's ghost. The KIMA case study provides a practical example of how immersion can be used to enhance the impact of presence experiences.

5.2 Audiovisual cues for Interactivity in PG-telepresence environments

Liu & Shrum's model discusses the concept of interactivity across three different dimensions. Applied to the context of Pepper's ghost, their discussion highlights some of the key features of successful Pepper's ghost setups: Like all telepresence systems, PG-telepresence consists of a two-way stream of audio-visual signals. An audio-visual transmission from one environment to the telepresence stage (recording or live data-streaming) is echoed by a feedback to the recording environment. Interactivity is facilitated by a low-latency, high-spatial frequency, audio-visual signal-response loop. In PG-environments, audience is mostly presented with life-sized, photo-realistic holographic projection in (near) real-time, with direct interaction possibilities through relay cameras. This basic configuration of two-dimensional telepresence can be expanded into "one-to-many" streaming facilities. For example, one single filming room can be used to broadcast to many PG environments (Compare: Indian Elections 2014, www.musion.com). Two PG environments can be used to directly stream to one another (M.I.A and Janelle Monae). This multi-dimensionality of communication is an important trait of interaction and one of the key factors of interactivity within the Standard Model, derived from Shrum & Liu.

Lower latency results in a higher degree of realism. The ability to converse in real-time is a key factor in conveying the illusion. A sense of delay on the other hand results in experiences of attentative disconnection (Sylaiou et al. 2008), and breaks the feedback cycle on a cognitive and emotional level. These temporal cues, build a second cluster of interactivity factors, concerning questions of communicational frequency, latency and immediacy. Their relevance becomes specifically relevant in the context of Pepper's ghost as they literally make or break the illusion of presence.

A third cluster of interactivity parameters can be comprised as control cues as described by Hwang & McMillan (2008). Typically, users observe a streamed image as perceived 3-

dimensional illusion within a dedicated stage environment, designed to blur the boundaries between reality and and virtuality. The projected image of a person appears to be physically standing within a carefully configured space. Optical depth cues, screen invisibility and limited signal latency further heighten the illusion of non-mediation. The level of interaction, the degree of control of any interactant influences the interaction flow. In the context of Pepper's ghost this element of control comprises factors such as freedom of body movement, direct eye contact, or even physical interaction with a virtual image.

The more animated the body language of a virtual presenter, the more eye-contact (gaze) is established, the more intriguing the illusion. A number of studies support this evidence: Garau, Slater et al. (2003) discuss the importance of gaze for presence. Bailenson et al. (2001) provide significant evidence for a link between social presence and gaze in the context of avatars. Blom et al. showed that physical interaction with virtual objects augments presence such as tactile collision (Blom & Beckhaus 2013). Summarising, we can differentiate between three key groups of technical factors of interactivity in the context of presence:

Dimensionality of communication: 2-way stream of communication in real time, immediacy of interaction

Temporal Cues: Synchronicity, limited latency in sound and vision

Active Control: Body language, eye contact, and spatial presence (including shadows) help to establish the experience of actual, physical interaction.

Like immersion and realism, interactivity is a key factor in creating a sense of presence. In the context of Pepper's ghost, this relationship is subject of the "Transmission" case study presented in Chapter 8. The more a user interacts within a PG telepresence environment, the more feelings of intimacy between real and virtual interlocutor seem to emerge. The hypothesis of a strong correlation between kinetic, physical or communicational interaction and presence will be evaluated in the "Transmission"- case study.

5.3 Audiovisual cues for Realism in PG telepresence environments

Realism is not essential for the generation of presence. Like presence co-factors immersion and interactivity, realism is just a component, not a single denominator of presence experiences. However, realism amplifies, contributes and augments the feeling of presence. Higher framerates diminish motion blur and result in a higher degree of realism (Watson et al. 1983). Accurate shutter speed ensures a crisp image (Watson et al. 1983). Image values such as colour depth, bit rate, or the recording data rate (Meylan 2006) contribute to image quality, in turn facilitating realism. Adequate lighting further enhances the illusion (Rademacher 2001, McNamara 2000, Mania & Robinson 2004). The more lighting for the projected image lines up with lighting of projection context, the more convincing the image appears. Colour intensity, colour directionality, colour hue and saturation of the virtual image can all be mapped to and aligned with the streamed footage (Shim & Lee 2012). Generated imagery requires adequate encoding and decoding compression as well as contributive data image transfer methods from encoder to decoder and the projector or primary image (Meylan 2006). This visual component is matched by efficacy of the soundscape to adequately represent the transmitted image (Storms 1998).

Richness of sound, echo, latency, tinniness of the sound - all these factors facilitate believability of an actuality, of immediacy of the projected subject (Davis 1999, Freeman & Lessiter 2001). Together, these audio-visual components create a formula that encourages users to suspend disbelief. Suspension of disbelief, i.e. the propensity of audience members to engage perceptively, cognitively and affectively with the illusion, is facilitated by a diminished role of the technology itself (Lombard & Ditton 1997). Like cinema audiences ignoring the screen that separates them from the narrative experience, (Mitchell 2011, Strait 2015), audiences of Pepper's ghost illusions ignore key technical factors such as self-enclosed spaces, dark lighting, or the nature of projection, reflection and refraction to engage with the mediated experience. Such combination of technical factors contributes to realism, resulting in the perception of a projected image as life-like, non-mediated, tangible.

Recording cues: Recording factors such as frame- & bitrate, shutterspeed, colour depth, focus,...

Lighting cues: Lighting fidelity in directionality, colour temperature, cone spread and attenuation,...

Image transfer: Progressive vs interlaced streaming, streaming bit rate encoding/ decoding methods, package sizes and codecs, audiovisual synchronicity et al.

Image quality: Resolution of projection and/ or display, sharpness, visual depth cues such as reflections and shadows, elimination of motion artefacts, believability of skin tones, etc.

Sound cues: Sound fidelity, elimination of sound artefacts, richness of sound, multi-dimensionality

Technical cues are complimented by perceptual and social cues, which further enhance the illusion. Social cues such as body language, wardrobe, etc. help to establish a psychological setting for individual perceptions of realism. As much as the subject matter preconditions a degree of realism in representation through familiarity, the audience's propensity to suspend disbelief plays a part.

Social cues: Believability of subject matter, propensity to interact

Suspension of disbelief: willingness of users to suspend disbelief

A range of audiovisual parameters collectively engenders, forms and informs the creation of realism in virtual environments including Pepper's ghost. On a technical level, recording, lighting, streaming, sound and display parameters contribute to the virtual imagery's audio-visual fidelity to the real world. On a subjective, perceptual level, psychological and social factors of individual audience member's and their propensity to suspend disbelief precondition the perception of realism. Realism factors are linked to but not necessarily limited to immersion and interaction. Aforementioned cues augment the perception of presence. It is through their interplay, balancing and fine-tuning of these factors, that presence is established between subject matter and participant. In day-to-day practice, telepresence environments have to be intuitive to use, easy to adjust and to modulate and effective in their impact on audiences and users. Telepresence is a communication experience, an unhindered two-way communication between different parties. Effective representation of a relayed image results in high gratification for audience and telepresence interlocutors alike. With ease of access to streaming environments and ever-increasing quality of display forms, improved perception of presence becomes more and more accessible to large audiences. Interactivity, realism and immersion can be seen as pillars, integral co-factors of presence. In this research, the phenomenon is discussed through the lens of Pepper's ghost as *pars pro toto* for virtual environments.

These three dimensions present a framework for discussion and a unit of analysis. On a practical level, optimising production standards leads to improved user experiences. Telepresence experiences around the globe are changing from a 2-dimensional into a spatial or 3-dimensional practice. On an analytical level, the discussion of telepresence across three core components facilitates coherence across a range of methods - quantitative and qualitative alike. This research applies the standard model to standardised questionnaires (i.e. Witmer & Singer's Presence Questionnaire), expert interviews or quantitative analysis (recollection factors, EEG data interpretation). Distinctive categories for analytic examination build an elemental, systematic tool kit for the evaluation of telepresence.

My hypothesis proposes an intrinsic link between three co-factors - interactivity, realism and immersion – and presence. Through a better understanding of constituents of presence, I am hoping to develop strategies to improve their impact on audiences - specifically in the context of PG displays and my creative practice. Over the next three case studies, I will test the proposed standard telepresence model and its co-factors through different research designs. These three case studies make use of a triangulation of methodologies to yield most reliable results. All case studies have been developed in a media-arts and telematic context.

The art group Analema Group was involved in the creation of all three artefacts, their visual implementation and their documentation. Case studies were developed specifically to probe the effect of immersion, interactivity and realism on user experiences. As producer of the projects, I have been solely responsible for the planning and execution of research criteria, development of evaluation methods, questionnaires and the implementation of the research design. The nature of this thesis, between art practice and academic research, led to a mixed method approach guaranteeing adequate choice of methods depending on variables examined and artistic context.

6. Methodology - Case Studies and Mixed Method Triangulation

6.1 Converging Art and Research

The immediate context of my research is media art, telepresence art and the exploration of new strategies in presence research. Two distinctive objectives, artistic practice and research, created tensions that proved enriching, yet not void of conflict: Whereas the goal of an art project is to develop a new form experience, the aim of research is to generate valuable data and ultimately falsifiable research results. Consequentially, these two objectives do not always go hand in hand. An existing body of literature on the relationship between artistic practice and research highlights this dilemma.

Linda Candy (2011) distinguishes between practice based and practice led research. The two are often used as interchangeable terms yet imply different connotations, and ultimately a different strategy. Practice based research is an original investigation, with the objective to gain new knowledge, whereas practice led research presents new strategies for improving practice workflow, optimising its impact. Practice-based research is primarily concerned with the generation of an artefact, of artistic or academic nature. Practice-led research demonstrates a new understanding for a production process. The main difference is the outcome: Practice-based research is concerned with the artefact itself, practice led research explores new strategies in the method of creation, effectiveness of the explored methods. (Candy 2011).

All three case studies left the confinements of these two distinctive models: All three were designed as art piece as well as research case studies on telepresence. In other words, research was at once practice-led -investigating practical improvements of the modus operandi- and practice based in the creation of an artefact. This process points to a third way, combining both objectives. Not merely means to an end, artistic practice informed the creation of knowledge. Vice versa, research influenced the art piece in the production process: Such a third way, could be categorised as “research-based practice”. Research based practice can be distinguished from practice-led and practice-based research, in that the outcome itself is the result of research. Practice is not secondary, but equivalent to the research. Public engagement and academic discourse inform different cycles of development. Knowledge is acquired through the discussion of an artefact, which in itself presents the result of a continuous discourse with the audience.

Research-based Practise

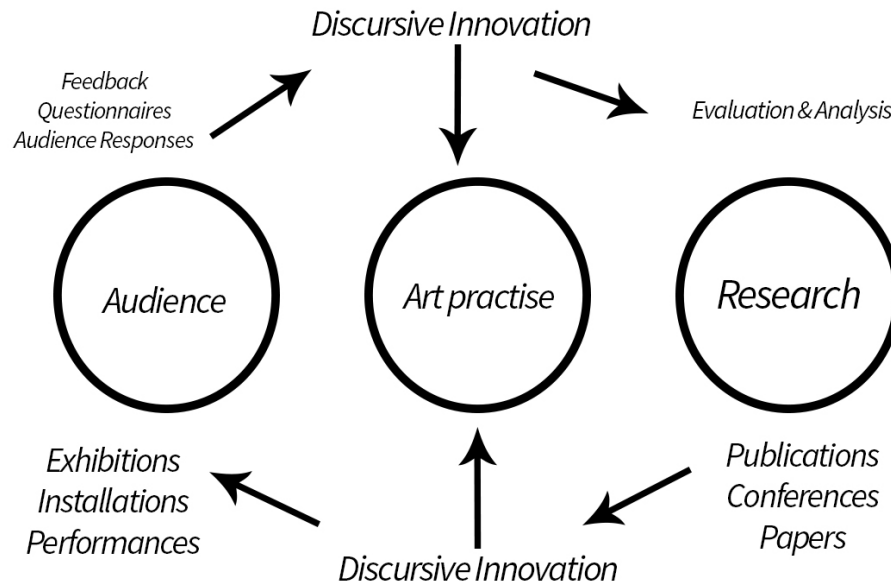


Fig. 16: Research-based Practice – Flow Chart

Donald Schoen's concept of reflection-in-action describes a similar strategy that helps to unveil some of the tacit knowledge in the creational process (In: Polanyi 1966). Verbalising the know-how involved in artistic practice inevitably changes the perception of processes employed. Reflecting on our actions means to contextualise, to critique and ultimately to improve the workflow. In the case studies conducted as part of this research, verbalising visual and sonic strategies ensured a process of self-reflective criticism in artistic decision-making. More than an internal, introspective debate, this discourse was fuelled through publications, resulting academic discourse and engagement with the public. This principle, referred to as "discursive innovation", is an iterative process that leads to a cumulative rethinking of the artefact itself. In "discursive innovation", the development process is enriched and furthered through research, publications, exhibitions and conferences. Third parties such as academics or the public incrementally influence this discourse. An influx of ideas, feedback and constructive criticism leads to improvements in the interaction design. The public plays a central part in "discursive innovation" of artistic practice.

Three case studies build the core of this thesis, as research framework and artistic output. Based on ongoing exchange with the public, "discursive innovation" formed,

contextualised and informed the body of work. Not merely l'art pour l'art, the art piece measures its effect on the audience, becomes subject matter of the research question. Importantly, this does not mean that the art piece is means to an end. Research, in turn, informs the creation process itself: Audience reactions are measured, feedback is taken into account, contributing to new cycles of artistic development. This iterative process of innovation through discourse, results in a feedback loop between research and creative development.

Donald Schoen (1983) introduced the concept of reflective practice, a method of verbalising and abstracting work processes. This method yields results through rationalisation and verbalisation - leading to improved workflow. Reflective practice is a cyclic development strategy based on permanent exchange with the public. Discourse is facilitated through public forums, papers and publications and not at least by evaluating audience responses through feedback forms and questionnaires. Such direct evaluation, be it through focus groups, through observation or interviews is then re-integrated into the optimisation processes of art piece and the research alike. Generation of knowledge is a defining principle, a declared goal throughout the creative process. The concept of "research based practice" understands creativity and research as equivalent objectives. Through the engagement with audiences as a constant, prevailing interlocutor, the artists' knowledge base expands increasingly. An adequate choice of research tools is therefore indispensable for the final result:

At the beginning of every research lies the pertaining, fundamental question of underlying concepts, terminologies and methodologies. The field of interactive arts cannot be seen as an isolated field: Telepresence discourse spans over an academic debate of 35 years, featuring an abundance of studies in various fields with diverging focus. The proposed standard model presents an attempt to simplify some of the complexities and redundancies, to clarify incoherences between co-existing models. Presence research is characterized by a large number of reoccurring patterns. Parallels and repetitions ask for simplification - a synthesis. Narrowing a very complex concept down to elemental factors assures analytical efficiency and provides a focused framework. The resulting model can only be tested, once applied to telepresence based practice. This research applies the proposed Standard Telepresence Model (STM) framework to my artistic practice.

On a conceptual level, immersion, realism and interactivity are discrete components of a complex, abstracted model. In practice, they are inter-related, and more hybrid than clear-cut definitions portray them. Applying abstract concepts to very concrete case studies, leads to an evaluation of its applicability in respect of my practice. Practice based research applied the STM framework to media art pieces in the context of my creative

practice. This quest led to a different understanding of presence, as not only passively perceived, but also actively produced.

The relationship between practice and research is never without tension: Practice-led research might reduce the artefact to the result of a laboratory experiment, rather than an art piece. In the Arts on the other hand, no audience member wants to feel like a crash test dummy in a research experiment, unless the research objective is made explicit from the outset. Fundamentally, in research-based practice, an artefact might serve first and foremost itself, along with aesthetic and conceptual objectives - before addressing any research questions. Artistic concepts were conceived as result of literature review, artistic engagement with contemporary or historic pieces, discourse with the audience and the result of an internal artistic debate within our collective..

While audiences were always made aware that the piece is part of a larger body of practice-led research on remote presence experiences, the act of evaluation was never just an afterthought, but always part of the concept. A considerable amount of time and effort was spent on finding a non-intrusive research approach that would allow audiences to perceive and reflect at the same time. Where research was kept separate from artistic practice, due to ethical reasons or to ensure reliability, objectivity and validity of results - the art piece became somewhat secondary to experimental engagement (Transmission & Aura case studies). A mixed method approach guaranteed a balance analysis through the triangulation of quantitative and qualitative methods. Adequate methodologies were used on a case-by-case basis, maintaining artistic integrity throughout.

b) Mixed Methods- Constructing Inner Validity

Research based practice is a process in which two objectives -art and research- exist side by side. Both aspects have one thing in common; they rely on underlying principles, abstracted theories that build their conceptual bricks and mortar. Art without meaning becomes design, research without theory is atomised, non-contextual and all too often meaningless. Over-arching concepts not only structure research, they build a link between micro- and macro-perspective within a debate and are thus fundamental to both research and artistic practice.

The three case studies presented in this thesis explore a number of methods to firm up this position. Mixed methods yield diverse sets of data, with the aim to falsify the underlying hypothesis. This thesis follows exploratory research questions on the relevance of the three co-factors of presence as denoted in the STM model: immersion, interactivity and realism. Such a mixed method approach serves the objective to

triangulate data sets, to compare and correlate answers to exploratory questions and ultimately to data sets concerning explanatory research. All three case studies combine different methods, synthesizing quantitative and qualitative approaches.

Current criticism in presence research focused on objectivity and relevance of measuring instruments as well as the cohesiveness of conceptual components (Floridi 2005, Slater 1999, Slater 2007). This thesis tries to avoid such criticism by using mixed methods depending on the type of question raised: Qualitative methods, such as expert interviews, focus panels and questionnaires and quantitative methods such as experimental designs, surveys, or a meta-analysis discuss telepresence both as a technical condition and as subjective perceptive phenomenon.

This thesis consists of a cross-case analysis of three case studies, each with an array of methodologies to answer the research question sequentially. Each case study is seen as ideographic as opposed to nomothetic research (Gagnon 2011). Ideographic research presents results in context, whereas nomothetic research extrapolates from exact results, to arrive at general conclusions (Franz & Robey 1984; Weick 1979). Yin defines a case study as the following:

“A case study is an empirical inquiry that investigates a contemporary phenomenon within its real life context, especially when the boundaries between phenomenon and context are not clearly evident.” (Yin 1994, p. 13)

Case studies are seen to fulfill at least four different uses: Firstly, they explain causal relationships in real-world interventions and their contexts. Case studies illustrate topics within an evaluation and lastly, enlighten situations where no clear outcome of an intervention can be ascertained (Compare Yin 1994). All three undertaken case studies are both descriptive and explanatory - with a mix of methods ensuring multiple angles: Case studies are understood as process of investigation (Creswell 2002), or as an object of research itself (Stake 2002) and can be further subdivided into three different categories: Intrinsic, instrumental or collective (Compare: Stake 2000, Yin 2003, Creswell 2002). Intrinsic case studies cannot be seen as *pars pro toto*, as synecdoche. Intrinsic case studies therefore don't intend to build or to contribute to theory. Instrumental case studies highlight a specific example that could be deferred into a generalizable theory. And last but not least, collective case studies compare multiple case studies in a collective analysis. Case studies presented within this thesis are of instrumental (KIMA, Transmission) as well as intrinsic nature (Aura).

Case studies can employ qualitative, quantitative or a mixed method approach. All three case studies presented here are using a mixed method approach, striving for convergence of research data: Numeric quantitative data, results of questionnaires and

an experiment are correlated and converged with qualitative research focusing on subjective perceptual experiences. The purpose of this concurrent mixed method study is to discuss the effect of immersion, interactivity and realism on presence for individual users of remote communication environments - specifically in the context of Pepper's ghost. All three studies employ quantitative methods to measure the relationship between the independent variables immersion, realism and interactivity respectively and the dependent variable presence. At the same time, the central phenomenon of presence will be explored using expert interviews and observations of artists and participants within the research environments. Correlating quantitative data sets and qualitative research methods compensates for the very subjective, perceptive nature of the phenomenon.

Pragmatism is widely understood as paradigm of case study research, and as overarching, theoretical pillar for mixed methods research (Patton 1990, Tashakkorie & Teddlie 2003). As an almost logical evolution of a school of thought, Macy related mixed method to classic and historic pragmatists such as John Dewey, William James or Herbert Mead. Together they share a focus on the research question. Assigning more importance to the research question, rather than employed methods, this paradigm underlies their method (compare: Tashakkorie & Teddlie 2003, p. 21). According to the pragmatists, all knowledge is conjectural. Under this premise, I chose to apply a mixed method approach to provide as much data evidence as possible to probe (and ultimately to falsify) the null hypothesis.

In this mixed method approach, the choice of methods is dictated by questions on "what to research" and "how to conduct research" (compare: Creswell 2009, p. 11) Accordingly, all three case studies use a different mix of methods to answer the respective research question - depending on the subject matter and the focus of the specific case study. Context is paramount in case study design: The ultimate goal is to further the understanding of a specific subject matter (Compare: Stake 2000),

I will now present objectives of all three case studies and corollary methods employed. In pragmatist tradition, the choice of research methods is directly linked to the consequences they entail. Subsequent triangulation of methods ensures a convergence of research data, and helps to bolster construct, internal and external validity alike. The theoretic rationale of this study follows the STM framework, exploring its legitimacy and effectiveness in respect of my practice. The STM framework presents three core components of presence as independent factors, with a dual objective as art and research projects.

6.1 Methodology: Effect of Immersion on Presence Experiences

The first of three case studies focuses on the presence co-factor immersion. More specifically, KIMA is centered on immersive sound as a mediator for telepresence experiences. KIMA, an art piece on the mutual relationship between sound and matter, was designed to discuss the role of sound in the creation of telepresence experiences. KIMA furthermore investigates the research question, whether immersion as evoked through multidimensional sound, affects the perception of presence experiences on Pepper's ghost displays.

KIMA was developed in conjunction with Analema group - myself, the artist Eugenia Emets, my supervisor Alain Renaud, and the programmers Joe Pochciol and Johnny Strutters as well as an array of performers (dance: Anna Buonomo, Dane Hurst; Singers: Victoria Cooper, Lani Rocillo and violinist Satoko Fukoda). Within this group I took the role of producer and have looked after the research proposition for KIMA throughout. KIMA has been shown twice at the UK's biggest festival for kinetic art - Kinetica - once as user installation, once as a performance. KIMA was presented at Siggraph and EVA London, the International Youth Arts Festival Kingston as well as at the ICT at London's Watermans Centre and has recently received Arts Council England Funding for the next development phase. The results of this first phase of KIMA were presented by Analema Group at the Bournemouth University's Festival of Learning and performed at Union Chapel London in March 2015 and Roundhouse Camden in August 2016. More than an art project, KIMA is a research environment on the role of immersion as a presence-generating factor.

The intention of the mixed method study is to test the theory of the standard telepresence model that relates the concept of immersion (independent variable) to presence (dependent variable). The two-tiered research evaluates the hypothesis of dependency and correlation between the variable immersion and the central phenomenon of presence. The corollary, explanatory research objective is to understand how immersion contributes to the effect of remote presence. Furthermore, it is the aim of the industrial sponsor, to discuss the phenomenon of immersion with the premise to explore its relevance commercially and to understand whether multi-dimensional sound contributes to presence experiences. This case study's proposition focuses on immersion, investigating whether this core component of presence can significantly influence and ultimately enhance presence experiences on Pepper's ghost displays and beyond.

Consequently, the hypothesis investigated follows the assumption that surround sound influences the perception of remote presence through increased immersion and its underlying factors. The pilot probes this conjecture by trying to answer exploratory questions on prevalence of a link between surround sound and presence experiences.

The hypothesis assumes a positive correlation between immersive sound and presence experiences. The pilot examined exploratory questions through a triangulation of qualitative methods: A focus group, observation and semi-structured expert interviews compared two-dimensional sound to immersive sound experiences. The intervention was staged as a performance, which took place in May 2013 at Musion HQ in Westcott House, Portland Place London in front of a selected audience. Following the intervention, a focus group session was orchestrated. Valuable input on the role of sound and immersion as contributing factor in telepresence was received by experts (see: appendix 4, the KIMA research evaluation for further information on the subject). This mix of method was purely committed to discuss exploratory questions.

The second part of this two-tiered study pursued explanatory questions, and was conducted at the Festival of Learning at Bournemouth University in June 2014. This second phase, concentrated on a structured survey - Witmer and Singer's Presence Questionnaire (PQ). The use of quantitative research methods ensured academic inter-comparability. Repeatability of the intervention guaranteed construct validity of results. Witmer & Singer's presence questionnaire has a high level of sensitivity with respect to underlying factors of presence and shows a internal consistency with a Cronbach alpha of $\alpha=.88$. The PQ survey was flanked by observation and interviews. By combining qualitative and quantitative methods, one can draw inferences on the role of immersion in the generation of presence. A case study research protocol guided the line of inquiry throughout and provided continuity in the pursuit of the research question. Converging both quantitative (numeric data) and qualitative data (observation, interviews), the KIMA case study provided conclusive results to validate the research hypothesis, interrogating the relevance of immersion as a co-factor of presence as theorized in the STM framework.

KIMA offers a real-time audiovisual environment, inviting either the public or a performer to investigate sound as an interactive, visual experience. Alain Renaud's sound design is relayed between two spaces: One space (Space B) consists of a sonic environment, the other is designed as visual interface (Space A) providing a local telepresence experience to the audience: In space A, a microphone input is used to transform sound into visual representations in realtime. Such visualisation patterns are based on cymatic formulas - mathematic equations derived from the laws of physics. Space B displays this immersive sound scape through a speaker array combined with a motion capture system: A dancer, performer or an audience member can interact with the soundscape from the primary room, modifying it through their movements in real-time. This setup creates an audiovisual feedback loop, a music instrument for body and voice as a telepresence environment for audiences in both spaces. Contrasting presence experiences between two locations, we can measure the effect of immersive sound on telepresence.

Focus groups are small structured groups with selected participants debating shared experiences through moderated interaction (compare: Litosseliti 2003). Focus groups were first introduced as tool of qualitative analysis, for market research and assessment of collective opinions by Paul Lazarsfeld and Robert K. Merton at Columbia University in 1941 (compare: Merton 1987, p.554). The term “focus group” however first came to prominence during the 1980s (Knodel 1987, Morgan 1988;) Morgan (1996) defines focus groups as research technique that collects data through group interaction on a topic determined by the researcher. Focus groups serve a purely academic purpose, are moderated and are characterized by an open, but structured discussion.

Inclusive and exclusive definitions of focus groups co-exist. Whereas exclusive definitions focus only on group-interviews that are conducted in informal settings, use non-directive interviewing, and use unstructured questions (Frey & Fontana 1991). Such limiting and narrow definitions have been heavily criticized, and a very broad definition has now been accepted in academic discourse by followers of a more inclusive definition. Focus groups typically range from 4-12 participants. In our case 15 invitees were recruited from the field of arts, media, and academia - a field relevant to this study. We carefully selected the invitees to ensure a relatively even spread in gender, professional status and an equal representation of the fields art, academia and media professionals.

The session lasted one hour, including the intervention. Questionnaires were handed out prior to the discussion so not to influence their outcome and to give participants an incentive to reflect individually on their experiences. A moderator ensured the continuous flow, prompted questions and initiated a debate among audience members. Focus group discussions were recorded and documented for later analysis. This focus group study along with observation of the intervention and a structured questionnaire (Appendix 4) was used to answer exploratory questions on the effect of immersive sound on presence experiences. We were expecting key data on whether presence experience and immersion were directly connected. The study, its technical setup, and the results are presented in the next chapter.

The second phase of the KIMA case study was conducted using the Wittmer & Singer presence questionnaire survey in a quasi-experimental setup during the Festival of Learning at Bournemouth University. This phase concentrated on explanatory questions with a specific focus on inter-compatibility and transferability of research inferences. The study was flanked by participant observation during the research setup in June 2014 as well as interviews with participants. The Wittmer and Singer Presence Questionnaire (PQ) has been established as one of the de-facto standards for presence research (Insko 2003). Although it has been criticized as self-referential and for its inability to differentiate

between reality and virtual reality (Slater et al. 2007), the PQ is still accredited with strong reliability (Youngblut 2004): Witmer & Singer's Presence Questionnaire maintains its role as established academic instrument, recognized for its high sensibility, construct validity, distinguishing between contributing factors of presence. Initially proposed in August 1992 by Bob Witmer and Michael Singer at the US Army Research Institute for the Behavioural and Social Sciences in Orlando was modified, adapted and optimized twice (Witmer & Singer 1998).

Originally, derived from a model of four factors, Control Factors (such as degree, immediacy or mode of control), sensory factors, distraction factors and realism, it was subsequently developed into the current model of several subscales. The presence questionnaire is now organized into seven subscales - Realism, Interaction, Quality, Examination, Self-Evaluation, Sound and Touch. The initial test with over 30 questions was subsequently reduced to 19 to assure ease of use. The score itself is constructed by summing mean average values of every question to a total score – the presence quotient. Measured on a 7-point Likert scale, the questionnaire is based on the semantic differential principle (Dyer, Matthews, Stulac, Wright, Yudowitsch 1976). Integral underlying factors constituting the presence score were largely derived from existing research. Grouping the presence questionnaire into clusters allows assignment to subscales, and guarantees higher construct validity for further analysis.

Utilising the presence questionnaire assured high construct validity, a degree of reliability, and objectivity. Presence questionnaires or post-immersion questionnaires have been tested for face validity, to effectively measure what they propose to measure. In 2004, the the Canadian "Institute for Cyberpsychology" at the University du Quebec Outaouais (UQO) validated the presence questionnaire (PQ). The UQO norm evaluates the questionnaire, in order to make it accessible to French speaking countries. In the process, the UQO established a mean average based on 101 participants in a large study encompassing multiple age groups with a distribution from 18-65 across a range of different media. The UQO norm was established based on a variety of VR systems, affordable HMD to high-end virtual environments to CAVE systems.

Stephane Bouchard, from the University of Quebec explained that the idea of the norm was to validate the Witmer & Singer presence questionnaire across different media, different strata "from healthy young adults to elderly and people suffering from mental disorders, and tasks (from experimental to clinical)". Due to this heterogeneous construction method, the norm validation provides a useful tool to compare presence scores. As a population mean average, the UQO norm is a benchmark for presence quotients, a norm for the assessment of successful presence experiences.

Although Witmer & Singer's PQ presents a very inclusive instrument to measure presence -offering a wide spectrum of subordinated factors- a number of difficulties were encountered in its use. Firstly, the instrument is considered a post-immersion test. Data input is therefore subjective to the participants and can be skewed by other factors such as time, external influences or researcher bias. Furthermore, the Witmer & Singer test has been criticized for measuring system properties (Slater 2007), rather than individual, perceptive reception of presence (Insko 2003). Relying on either 32 or 19 questions to be answered on a 1 to 7-point Likert scale, the questionnaire is not only complex and thus time-consuming to fill out, but also wordy, without offering users explanation on terminology.

To avoid misconceptions, I analysed all questions with my research team, crosschecking for their suitability, offering further explanations to the users wherever required. Certain questions were not suitable for our specific presence setup (factors referring to touch), others had to be adapted or explained in the context of the research. Despite its nature as a multi-faceted survey instrument, the Witmer & Singer questionnaire proved prohibitively lengthy to be practical within the research environment. Witmer & Singer's PQ can only be regarded as useful in conjunction with other research methods through triangulation of results. In the KIMA case study, the Presence Questionnaire evaluation was therefore converged with participant observation and interviews. Triangulation of methods warranted contextualisation, and increased external and construct validity of methods.

Participant observation is typically performed as part of a case study (Jorgensen 1989, Becker 1968). Participant observation is typically performed by "insiders" in a natural setting, with theorizing and interpreting direct observation of human actions and interactions as a key method within a case study design. The method of participant observation furthers the triangulation of data and the building of theory.

The full case study report is presented in the next chapter - it includes the evaluation of both pilot and case study questionnaires, analysis of the interviews, conceptual overview and observations on both field experiments. Transcripts of the interviews can be found in the appendix along with both questionnaires and video documentation of both installations.

Case Study I - Mixed Methods

Research Question: Surround sound influences the perception of remote presence through increased immersion.

N0: Surround sound does not positively affect the perception of presence in a remote location.

Phase 1 - Pilot: Exploratory Study - Arts Council Screening

Independent variable (immersion) dependent variable (presence), control variables (inclusion, extensive cues, surrounding cues, vivid cues) social cues, attention, temporal cues.

Sample: 10-15 Media Arts Experts

Baseline: 2D sound at start of the experiment

Control Group: 2D sound

Independent Variable: Immersion

Dependent Variable: Presence Experience (measured through questionnaires and interviews)

Confounding Variable: Latency

Phase 2 - Case Study: Explanatory - Festival of Learning

- Presence Questionnaire
- Field Study / Observation
- Interviews
- Evaluation Factors: inclusive, extensive, surrounding, vivid cues - social cues, attention, temporal cues.

6.2 Transmission - Researching Interactivity in Presence Experiences

The second case study is dedicated to the exploration of interactivity as a co-factor of presence. Criticism of presence research lamented the missing accountability of subjective instruments such as the Witmer & Singer Presence Questionnaire (PQ). As pseudo-objective measurement, presence questionnaires only capture subjective experiences. Critics such as Cambridge's Floridi argued that only the use of quantitative research data such as heart beat measurements, eye movement tests, memory tests or EEG data could objectively measure presence (Floridi 2005). This argument suggests that the use of "objective" quantitative data guarantees construct validity, significance of results and helps to avoid researcher bias or participant-observer influence on data acquisition.

The Transmission case study presents a research environment that sets out to explore the effect of remote, physical interaction on the human mind. The impact of interactivity is measured quantitatively through biometric EEG data analysis. Participants' brainwave stream is interpreted and displayed on an audiovisual interface, accessible to the participant and a remote user. Within this networked, real-time installation, users in two rooms are interacting with one another: The user in space A, wearing an EEG headset, triggers real-time visualisation and sonification of his brainwaves. Motion capture data of a user in space B manipulates this representation in real-time. Data before and after the intervention is compared for a significant difference. The experiment is conducted as a paired T-test, an analytical tool that compares trials across one and the same sample across time. Statistic analysis searches for any meaningful change in datasets (with a

confidence interval of 0.95%), rendering the use of a control group negligible. Using pre-intervention data as baseline recording, the initial representation acts as an autopoietic, self-directed mirror image of the EEG-wearer. Any deviation from the baseline recording can be analyzed with help of a T-test as effect of the intervention. Transmission presents a feedback loop of physical interaction, and “passive” perception in telepresence experiences.

An exploratory pilot tested functionality and efficiency at the Transmission symposium, Bournemouth University, in February 2015. The actual case study was conducted as quasi-experimental research setup at Bournemouth University in March 2015. The experiment evaluated brainwave activity as control variable on 15 participants. The convenience sample was drawn directly from the University, not taking any randomization into account (quasi-experiment). Interactivity, defined as independent variable, and presence as dependent variable were measured through the Witmer and Singer Presence Questionnaire (PQ). The dependent variable is controlled through brainwave stimulation with intervening/confounding variables of latency, user control and directionality of interactivity. The case study's proposition is that interactivity as a co-factor of presence, as proposed by the STM framework, can significantly affect presence experiences. Understanding the effect of direct, bodily, interaction on the human brain better, will help to improve presence experiences in future installations on Pepper's ghost interfaces and beyond. The quasi-experimental setup was accompanied by participant observation and an analytical evaluation of the questionnaire.

The purpose of the mixed method study Transmission is the examination of the standard telepresence model as analytical tool in respect of my creative practice. The STM framework associates interactivity with presence as a cofactorial component. By establishing whether bodily interaction influences presence, networked environments profit from the acquired knowledge pool. At present, commercial applications such as the Cisco telepresence suite present interactants as relatively static: Fixed on a chair, participants are moving as little as possible, so to remain within the image frame. Should kinetic movement contribute to presence, a larger degree of freedom for body movement could enhance presence experiences dramatically. It is the commercial and industrial intention of the industrial sponsor to explore the role of interactivity so to facilitate optimised telepresence experiences. Through the use of EEG data, simple information on user engagement can be extracted in numerical form. The case study follows the STM framework deductively and probes its validity in the context of my media art practice.

The hypothesis is derived directly from the STM framework and assumes dependency between interactivity and presence experiences. To reverse the onus of proof, the null-hypothesis states that increased interactivity does not improve presence experiences.

Absence of physical interaction would not lead to different results from presence experiences *with* real-time kinetic interactivity. A mixed method strategy was used to investigate this assumption and to probe the null-hypothesis for falsification. A paired T-test compared population means within the sample before and after the intervention. Participant observation and analysis of the Witmer & Singer presence questionnaire converged research results. Prior to the actual case study, a pilot was used to examine explorative questions, and to establish the suitability of the research setup.

Ascertain Transmission's adequacy as research instrument, the pilot was not at least a technical "dry-run" for the quasi-experimental case study. Unsurprisingly, the pilot indicated significant technical flaws in the research design and led to further improvements prior to the experiment. Transmission relies on a prosumer EEG headset – the Epoc Emotiv (www.epoc.com) frequently used in academic contexts. The first power-spectrum analysis as introspective monitoring instrument dates back to more than 30 years ago (Otto 2007). With 14 nodes, Epoc's Emotiv-EEG generates complex data, and has been validated for academic research by multiple studies (compare Chapter 8).

Statistically, this data was analysed using a paired T-test, often employed in clinical trials. The paired T-Test or Student's t-test is typically used when analysing the same sample in a before-after comparison (Rice University 2015). King (2008) argued that the student t-test's compared to non-similar tests still shows to be uniformly most powerful (UMP), specifically when applied to larger sample sizes. Small sample sizes in Student t-tests may lead to Type-I errors, assuming an effect exists when there was none. Type-II errors can arise from small samples too, disregarding a potential effect, when actually there was one. DeWinter, from Delft University of Technology challenges the view that very small t-test samples lead to higher Type-I or Type-II error cases, given within-pair correlation of data is high (De Winter 2013, p.2).

The Transmission case study sample of N=15 was large enough to avoid a challenge to construct validity. A Cronbach alpha value of 0.8 indicates comparably large reliability. Cronbach's alpha, developed by Lee Cronbach in 1951 is largely regarded as indicator for internal consistency of a test, measuring the co-variance between items, the variance of the total-score as well as the number of items used (compare: Bonett 2010, p.368-385). Student T-tests tend to be accompanied by Confidence Intervals (CI) to determine their statistic significance. In academic practice, a confidence interval of 95% is considered statistically significant. Degrees of freedom are defined by the sample size N-1. In the case of Transmission, the T-test was conducted with 14 degrees of freedom. . All statistical data evaluations, as well as the Witmer & Singer presence questionnaire and its evaluation are published in the Appendix.

The Transmission case study used a combination of qualitative and quantitative data to examine one of the co-factors of presence experiences. Interactivity as conceptualized within the STM framework relies on constructing variables that determine its impact. A key weakness of domineering conceptualizations of interactivity is the reliance on a model that was developed in the field of online research. However, intervening variables time, dimensionality of communication and active control proved useful in guaranteeing external validity and inter-comparability of results. Intervention data was recorded for later analysis, but exempt from video-recording or video publication due to ethical concerns. The experiment was followed up with a structured questionnaire, the Witmer and Singer PQ. To be able to converge quantitative with qualitative data sets, participant observation was included in the case study. Triangulation of research data results builds the cornerstone of explanatory interpretation of research results

The Witmer & Singer Presence questionnaire with its abstracted framework only yields relevancy results once viewed through this lens, by convergence of data generated through qualitative participant observation. A Participant observation relies on a case study design to lead to theory building, conclusive results. Furthermore, participant observation builds on subjective feelings, personal values, and interests (Krieger 1985; Johnson 1975a, 1977b). Heterogeneity of responses made participant observation ever more relevant for theory building. The phenomenological remit of participant research, means that indicators of presence, audiovisual cues and components of interactivity are questioned with regards to their meaning rather than a quantifiable sum. Full documentation of the experiment, the pilot and all corollary qualitative research results can be found in the following chapters and the appendix.

Transmission has been presented at EVA London, the British Computer and Arts Society's annual conference, Siggraph 2014, in MIT's Leonardo Journal and was presented at Kinetica Art Fair 2014 and the Transmission Symposia on the 4th of February 2014 and on 22nd of April 2015. The Transmission Symposium discussed a symbiosis between the Arts and brainwave research. The symposium led to a growing online community of media artists and neurofeedback researchers. Continued interest in the possibilities of brainwave art shows the relative success of this case study in stimulating a discourse that goes beyond the medium of Pepper's ghost.

Case Study II - Transmission - Mixed Methods

Research Question: How does interactivity influence the perception of presence?

Methods: Experiment / Interviews / Observation

N1: Interactivity positively influences the perception of presence through dimensionality of communication, temporal cues, active control.

N0: Absence of interactivity yields the same results as presence experiences with interactivity
Sample: 20 Students

Baseline: Recording of people experiencing their own brainwave visualisation
Control Group: Recorded interactivity

Independent Variable: Interactivity
Dependent Variable: Brainwave data
Mediating Variable: control, dimensionality, temporal
Mixed methods, sequential study

Phase 1 - Pilot Study - Exploratory - MDH Headoffice - mixed methods

- Quasi- experiment
- Observation
- Interviews

Measuring Engagement and excitement levels through EEG, baseline figure through non-interactive mode; control group (non interactive)

Phase 2 - Case Study -Explanatory Bournemouth University - mixed methods

- Experiment - Establishing causal relationship
- Presence Questionnaire
- Observation
- Evaluating Key Factors - communication, temporal cues, active control.
- Sample of 15 people.
- Paired T-Test
- Presence Questionnaire dimensions

6.3. Aura - Exploring the Role of Realism in Presence Experiences

The third case study, entitled Aura, is concerned with the role of realism in the creation of presence experiences. Realism or fidelity to the environment is conceptualised as third component of presence within the proposed STM framework. Because of the multitude of factors contributing to effectiveness of realism, the methodology of this case study reflects this complexity. A systematic meta-analysis, presents an extensive perspective on the subject-matter. This case study utilises a Cochrane-style meta-analysis approach as structural outline. The use of a tested, taxative framework ensures construct validity and external validity in the analysis. An art piece and its participant observation as well as a small focus group study contextualise the subject in the framework of Pepper's ghost.

The "Aura" meta-analysis is divided into a statistic and a narrative component and embedded in a focus group discourse with structured interviews. Comparing different presence factors, experts interviews are triangulated with artistic examples reflecting the role of realism in art practice on Pepper's ghost. A practical exemplifier, the art piece "Aura", questions the conceptual limits of realism.

The art piece “Aura” scrutinises what realism means in the context of presence, negating the necessity for visual properties, visibility of realism in its conceptualisation. As a *contraditio qua non*, Aura shifts the focus of debate from visible, to invisible, from covert to hidden: Here, realism is not necessarily understood as visual, physical, quantifiable property. Instead the case study proposes a new understanding of realism as fidelity, accuracy, truthfulness to the real world. The practical example builds the narrative arch within this debate. The research combines exploratory questions (Meta-analysis, focus group) with explanatory questions.

The purpose of the mixed method case study Aura is to investigate the theory of the standard telepresence model that associates the concept of realism with presence experiences. Discussing strategies to augment and enhance realism in virtual environments should help to augment future telepresence installations on Pepper’s ghost and beyond. Expert interviews, a systematic meta-analysis and participant observation of the art piece focus on realism on Pepper’s ghost displays. The “Aura” case study analyses realism as core-component of the STM framework across seven different factors. A deeper understanding of realism and its underlying factors as presented in the STM framework can influence and optimize the design of future virtual telepresence environments in respect of my practice. It is the industrial purpose of this study to provide a solid discursive framework for such an augmentation of presence.

The meta-analysis builds the formal and informal backbone of this research. Meta-analysis is conceptualized as a statistic tool to synthesise results of two or more studies. Glass (1976) defines meta-analysis as “the statistical analysis of a large collection of analysis results for the purpose of integrating the findings.” Most meta-analysis studies compare weighted average of effect estimates of different studies while compensating for heterogeneity (Cochrane.org 2015). Whereas informal meta-analysis simply enumerates different studies pertaining to one and the same field, presenting sample size, method and results, a formal meta-analysis compares study results statistically and infers conclusions from the combination of results (Monroe 2007). Meta-analysis is first and foremost a quantitative instrument to synthesise independent studies, exploring heterogeneity and summarizing their combined results by measuring effect sizes.

Prof. Nandy Karabi from the University of California Los Angeles, explains an effect size as a combination of effect, i.e. a change occurring as direct result of an intervention and its size: An effect size is “simply a way of quantifying the size of the difference between two groups” (Karabi 2012). Effect sizes are usually measured as Cohen’s *d* between groups, Pearson’s *r* and *R* square in Regression analysis or Cohen’s *f* square. Pooling of

research results from multiple studies is not only difficult due to the variety of methods available to calculate effect sizes:

Criticism in meta-analysis is concerned with dual-standards proposed: While pretending to be objective, they are in fact, relying on a selection process, which in itself could introduce researcher bias (Rothman & Greenland 1998). Narrative reviews lack rules of inference for theory building and analysis. Consequently, the onus of proof relies heavily on the researcher itself. Secondly, heterogeneity of samples, not only in sizes, but in the variation of study populations is a problem for the estimation of variance (Kaizar 2005). Furthermore, criticism of meta-analysis concerns the fact that meta-analysis studies often conflate different studies that measure entirely different things, figuratively speaking comparing apples with oranges. Meta-analysis often fails to ensure that weighed study effects actually measure the same idioms, and not conceptually different ones. A meta-analysis tends to follow a very rigid analytical structure, derived from a pre-dominantly clinical background.

The quality of report of meta-analysis statement –in short Qurom statement – was the result of a conference of 30 experts, first published in the Medical Journal “The Lancet” (Moher et al. 1999). The Qurom statement provides a checklist of how to provide abstract, introduction, methods, results and discussion of a meta-analysis report (Clarke 2000). The case study on realism report largely follows this structure, specifically a Cochrane-style structure. The Cochrane collaboration is a network of almost 37,000 contributors from 130 countries providing “authoritative, relevant and reliable evidence in the form of Cochrane Reviews (Cochrane.org 2015). Cochrane reviews have a remit that exclusively focuses on health care, and “the effect of interventions for prevention, treatment and rehabilitation” (Cochrane.org 2015). In order to be published within the Cochrane Library, an organization needs to be Cochrane approved, which hasn’t been the case for my faculty. Neither is the concern of this study health-care. Although instruments applied within this research follow a very systematic, “Cochrane-style” procedure, its structural presentation is carried slightly in favour of a more explanatory approach. Every meta-analysis meets challenges: A meta-analysis has to provide an overview of the status quo of existing research, within a reasonable scope of the phenomenon. Secondly, a meta-analysis needs to explore explanatory and response variables. This means that a large number of studies might have to be discarded from primary research, if such variables are not their actual subject matter. Thirdly, inclusion and exclusion criteria needs to be explicit, so to be clear on the elimination process. The Aura-case study attempted to meet these challenges:

72 studies were included in the initial review. Only 37 of these met formal selection criteria and were admitted into the master catalogue. The master catalogue was further

scrutinised, structured into categories and presented as informal meta-analysis review. Although not all studies provide enough statistic evidence to be included in the formal review, they highlight aspects of realism as discussed in the proposed Standard Model and are valuable to further discussion in the context of this paper. The master catalogue is illustrated further through examples of media art in the context of Pepper's ghost. Only a very small number of studies, ten in total, was finally included in the formal research. A further two had to be discarded not meeting all necessary formal requirements. The complete meta-analysis report consisting of formal and informal analysis is converged with qualitative research. This mixed method approach combines participant observation and a focus group study, both presented within the case study report.

The hypothesis assumes a fundamental, positive relationship between realism and presence. A heightened degree of realism would correspond to a higher degree of perceived presence. The null hypothesis on the other hand postulates a non-existing link between presence and realism. A mixed-method approach has been used to probe the validity of this assumption, testing the null-hypothesis for falsification.

The analytical part of this case study is flanked by a media art proposition, Aura, developed as a more intro-spective interface for brainwave analysis, a counterpoint to conventional perceptions of realism and a trigger for future debate on the limits of realism. Aura has been presented at Bournemouth University's Festival of Learning on the 15h of July 2015 and at Kinetica's Gravity show at the Hospital Club, Covent Garden, London, in October 2015.

Research Question

How does realism contribute to the perception of remote presence?

Method: Meta-Analysis /Participant Observation / Expert Interviews

N1: Realism conveyed through specific audiovisual cues and production standards positively influences remote presence experiences.

N0: Realism does not influence remote presence experiences:

1. Meta-analysis: Balance parameters / Cochran group style meta-analysis
2. Expert Interviews: Sample: 10 Media Experts
Intervention: Compare presence factors side by side on Pepper's ghost display
3. Participant Observation: Analysis of audience interaction with the art piece "Aura"

Together, the three case studies describe the three co-factors of presence in practice and research. The STM model does not pretend, let alone aspire to be a complete, comprehensive model for presence or to subsume all components under its umbrella. The idea is, however, to simplify the analytical framework and to conceptualise underlying components of presence in a constructive, yet critical manner in respect of my own creative practice. Such an in-depth, multi-dimensional discussion opens the door for future developments. Kima, Transmission and Aura are not only three case studies, with a discursive, analytical agenda, they are first and foremost art pieces – with the intention to trigger a wider debate on perception of presence in media arts.

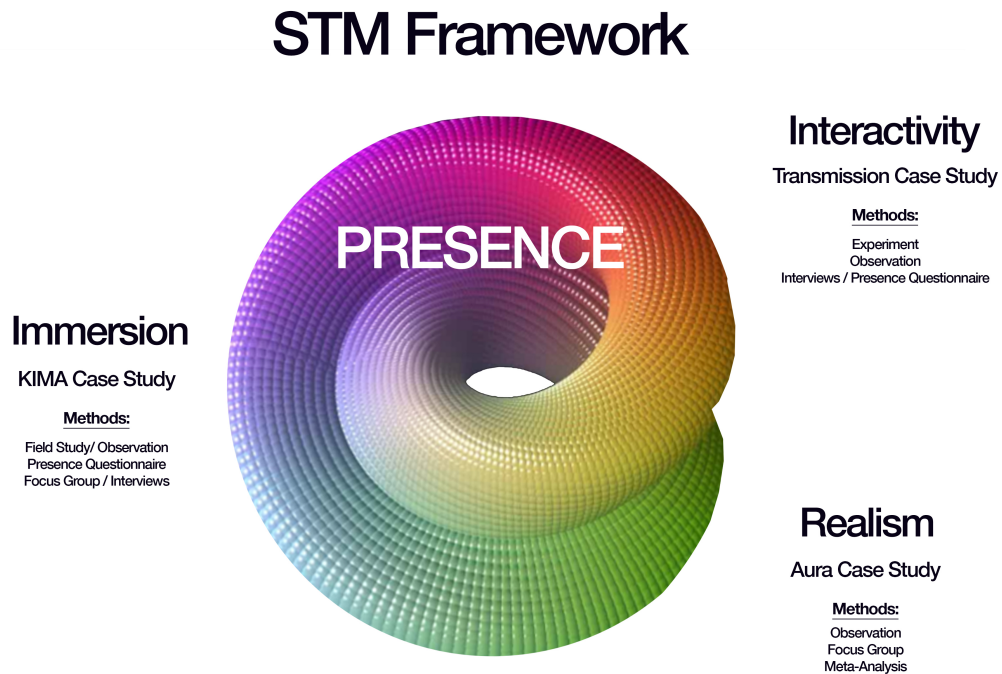


Fig. 17: STM - Case Study Attribution

7. KIMA / Immersive Sound as Presence Generating Factor - Case Study I

Sound is a core component of interactive engagements in mediated realities. Furthermore, sound and more specifically surround sonic experiences are key contributors to immersion. A number of studies investigated the combined influence of sound on presence (Davis 1999, Serafin 2004, Freeman & Lessiter 2001). In the presented case study, spatial sound, telepresence experiences are compared against directional sound. Presence is understood as an audio-visual, i.e. multi-sensory phenomenon, in which sounds plays a particular role as facilitator of realism, interactivity and not at least immersion. The premise of this case study is to test the importance of immersive surround sound against two-dimensional sound to gain insight into the role of *immersion* as an instrument to generate and ultimately improve presence experience.

Academic research on the role of surround sound in telepresence remains rare, inconclusive and inconsistent (see: Lombard & Ditton 1997). A number of scholars discussed the effect of audio-spatialization on presence, for instance Reeves, Detenber & Steuer (2008), Freeman and Lessiter (2001) and Bormann (2005). Karsten Borman's findings looked at the difference between attenuated and non-attenuated sound, showing that attenuated sound has direct impact on involvement and presence. Freeman and Lessiter on the other hand, were unable to prove a positive correlation between surround sound and presence. Can surround sound play a role on a subliminal level? Is surround sound perceived as stronger contributing factor than bi-directional sound? The KIMA research design, investigates these questions by presenting an art piece that alternates between surround and 2-dimensional sound, contrasting their effect.

The research and art project KIMA was presented at Slggraph, the British Computer and Arts Society, Kinetica Art Fair, the Union Chapel London and received a research grant by the Arts Council England. KIMA questions the relationship between sound and vision on an artistic level. At the same time, KIMA contributes to the discussion on sound as co-factor of presence in networked installations or remote performances. The use of Pepper's ghost displays allows for real-time interaction and its integration with remote representations of sound. The aim of this research is to deconstruct, analyse and better understand the relationship between sound and vision and the effect that immersive sound has on the impact of presence experiences. KIMA controls for realism factors, eclipses other co-factors of presence, thereby focusing exclusively on sound as transmitter of presence. Fundamentally, this case study scrutinizes the hypothesis of a measurable relationship between immersion and presence.

7.1 KIMA – a telepresence setup for audiovisual sound perception testing

The word Kima quite literally means wave in ancient Greek. With Analema Group, a team of researchers, artists and scientists has made cymatics, the study of wave patterns, the conceptual and theoretic framework of an audiovisual piece. In this telepresence research environment, users perceive the waveform both in its sonic and its physical form as a travelling, ever changing stimulus, as an interface of actions and interactions within a telematic performance setup. KIMA is art and research project at once, probing remote sound visualisations as means for remote presence experiences. As an art project KIMA creates a unique telepresence environment for its audiences, based on mathematic and visual qualities of sound. As a research project, KIMA discusses the effect of immersive sound on telepresence perception.

KIMA presents a telepresence environment for two or more participants in which sound is visualized through live input (voice, percussion) as well as interaction (motion control). The effect of sound as a telepresence component is then tested through questionnaires and standardised tests. KIMA has been presented multiple times to the public. The case study has been conducted as two-tiered, sequential research. The first phase was presented to industry experts at Musion head quarters in May 2013. The second tier was conducted at Bournemouth University's Festival of Learning in May 2014.

Very little research on the impact of surround sound on presence exists in current academic debate. Even though the relevance of sound in creating presence is uncontested (Lombard & Ditton 1997, Williams & Christie 1976), important questions maintain unanswered. Specifically, the role of immersive sound within presence research remains opaque. Little research is available, and some of the exiting findings is contradictory. Detenber and Steuer (2008) found no notable difference between 2-dimensional and 5.1 sound. This case study concentrates on sound not only as a component, but as single constituting transmitter of presence. In KIMA, sound acts as a mediator between two rooms and two or more performers, without sound there is no virtual representation, no presence. KIMA is more than a mere artifact, the technical design allows to test the effect immersive sound has a component of presence.

This two-tiered research design concentrated on the subject in an initial exploratory phase, followed by a subsequent explanatory phase through a mix of method triangulations. In the exploratory phase, the research focus is exclusively interested in differences in perception between surround and 2-dimensional sound. The second phase, probes the hypothesis with statistic instruments, following explanatory questions.

7.2. KIMA - Artistic Concept

KIMA contrasts sound and vision as two distinctive, yet intrinsically interrelated phenomena. Cymatics, the science of visual wave, can be dated back to Ernst Chladni's experiments of the 18th century. This fundamental link between sound and matter, builds the conceptual dichotomy for the piece: Two remote spaces are representative of these dimensions - one relating to sound, one to its visual interpretation. Users are experiencing the nucleus of remote communication across these spaces as an echo, a vague sense of presence of another person in real-time. Create sound in one space, participants perceive its visual properties on a Pepper's ghost display in a second environment. KIMA maps sound geometrically across these two spaces - allowing users to reference one another, facilitating interaction through sound and movement. KIMA invites the audience to play with body and voice as instrument in space. Participants thus become an artist in their own right.

Conceptually, a number of artists focused on sound waves as either visible or invisible structure of our communication. Bernhard Leitner's "Sound Cube" (Leitner 1970) used surround sound to immerse users in the experience of "geometric" sound, a sound architecture to walk through. David Bowen's "Telepresent Water" (Bowen 2011) made use of water currents to deform a geometric structure at a remote location.

The art and research collective Analema Group decided to use cymatic wave patterns in sound and image as a mediator for remote interactions. The term cymatics derives from the Greek word κύμα "wave" and was first introduced by Hans Jenny (Jenny 1967). In brief, cymatics is known to be the science of visible sound waves – normally manifested by nodal lines of particles or liquids within rigid environments as the result of sonic vibration. Hans Jenny, the father of this field of study, experimented with Chladni plates in the 1960s and 1970s. Chladni plates are fixed, contained environments, normally metal plates or container surfaces used as a mediator to research the effect of frequency vibration on particles or liquids. Ernst Chladni (1756–1827), the founder of Acoustics, was the first to research vibrations and their effects on sand within rigid surfaces. Chladni demonstrated his famed laboratory setup at the French court and catalogued his studies to a certain degree.

In the 1960s, these experiments were further developed and academically contextualised by Hans Jenny. Jenny looked at regularities in visual patterns and established a formula that links frequencies to visual patterns directly. His research and publications, the catalogue of wave patterns formed an atlas – a backbone for future research by academics, musicians and artists. György Kepes, Founder of the Center of Advanced Visual Studies at the MIT, Derek Kverno and Jim Nolen at Davidson and Thomas Cooper at Temple University all researched the subject. Recently Lewis Sykes from the Manchester Institute for Research in Art and Design investigated the subject matter in

artistic and theoretic practice. On a mathematical level, cymatic patterns have been discussed by Stewart and Colwell (1939), by Elmore and Head (1985) and maybe most importantly by Paul Bourke, Research Associate Professor at the University of Western Australia.

In laymen's terms Cladhi patterns describe the movement of sound across rigid surfaces, at the acceleration of sine waves in a constraint environment such as a rectangular or a round plate. Vibration patterns depend largely on the frequency itself as well as the rigidity of the surface and its confining boundaries. Modal residues settle where the speed of these frequencies equals zero. These points of zero acceleration are generally ordered symmetric "lines" arranged towards the centre. Researchers have applied this model to the 3-dimensional space (see: Paul Bourke et al.), the point of departure for the KIMA project. On a phonetic and symphonic level, R. Pellegrino's studies on "The Electronic Arts of Sound and Light" (1983), Alvin Lucier's composition "Queen of the South" (2009) or Lewis Skyes "Augmented Tonoscope" (Sykes 2015) stand out as artistic interpretations of the subject. In the arts, Carsten Nicolai's "Milch" (2000) or Graham Wakefield's Chladni 2D and 3D Max/Msp (2012) patches have touched on the field of cymatics.

Cymatics have influenced artists and researchers alike. Observing cymatic patterns on a plate or in a volume means to inspect the intrinsic relationship between sound and sight. A Cladhi plate ultimately acts a medium for two dimensions, as a mirror of their relationship. Experiments in synaesthesia, art on the intersection between sight and sound date back even longer: Newton conducted research in physics, Mondrian or Kandinsky explored synaesthesia on canvas and composers like Louis Bertrand Castell engaged in this discourse through music. Mary Hallock-Greenwalt's colour organs "Sarabet" and "Nourathar" were able to create sound while displaying images, serving as a performative instrument and a display at the same time. In video and installation art, the long standing tradition of synaesthetic experiments is spear-headed by Oskar Fischinger, Norman McLaren or John Whitney Sr. & Jr. Standing in this tradition, KIMA tries to be more than an audio-visual instrument for the body: It is an instrument for two, a perpetual composition, in which the user becomes the composer and interactions become visual symphonies.

Conceptually, on both the sonic and the visual level, KIMA's underlying code is based on the physical principles of cymatics, wave arrangements resulting from transformations of frequencies and amplitudes. Mathematically correct formulas build the framework for these visual cues, which emerge in real time as a representation of the invisible on the Pepper's ghost interface. Whereas one space allows for sound as sole reference of presence, the second space displays a visual structure, a sound sculpture. Sound becomes a constructor of particle waveforms on the holographic projection environment.

The geometry resulting from flow of these particles is mathematically based on the joined soundscape, as well as the position of the other in a remote location. Exploring both spaces, visitors feel the difference between sonic and visual presence. Both phenomena, cymatics and telepresence, have a long tradition in the visual arts - both concepts have changed and evolved dramatically over time.

In contemporary art production, cymatics, as visualization of phonetic waves - have been the inspiration of artists around the globe: Recently, Paul Prudence "BioAcousticPhenomena" (2010) created visual references on cellular phenomena based on cymatic principles. "20Hz" by Ruth Jarman and Joe Gerhardt (2011) presented cymatic patterns in the context of media art. Lewis Sykes showed "Cymatic Adufe" at the Palacio des Artes in Porto and the Manchester Gallery (Sykes 2012).

In KIMA, the space itself and its exploration are central. 'Invisibility' has been explored in contemporary art production and display. The Hayward Gallery's "Invisible – Art about the Unseen 1957-2012" was entirely dedicated to that theme. Jeppe Hein's "Invisible Labyrinth" (Hein 2005) for instance, explores architectonic presence through movement and sound relays. In "KIMA" – communicative clues are of dual nature: On the one hand side, users communicate with the space around them. They enter an invisible construct confined by the physical borders of space – every movement induces a change in this sonic environment of echoes, frequencies and its geometrical attributes in the physical space.

The second communicative layer is the interaction with the other. Location references of the other are generated through sound panning, mapped onto the participant's environment. Location cues are augmented through echoes, frequency changes and the fact that interference patterns of sound, coincidences of communication can be seen or heard. These patterns are visually represented through cymatic patterns, visible sound geometries and their mathematically accurate representation in space. Projected into a holographic projection environment, the Pepper's ghost interface, these patterns are relating directly to the sound input emanating from the first space - be it through movement or direct sound input. Feedback signals allow participants to communicate using surround sound and its visual representation as an interface to generate remote presence.

Non-communication is virtually impossible as users are constantly exposed to a stream of information, audible and/or visible in their two spaces. Users thus act as a theremin, an instrument, a medium as well as a modulator of the visual form. The project plays with the duality of self and environment, sound and vision, the visible and the invisible. In this case the invisible existence of wave patterns which surround us. In KIMA, we transcend the boundaries of the physical space to communicate with similar spaces through difference patterns - alternative manifestations of presence.

Musion's Pepper's Ghost telepresence interface tends to depict life-sized, photorealistic human interaction. A dedicated back end codec solution facilitates streaming in real-time from a bespoke telepresence recording suite to the Pepper's Ghost display (Musion Eyeliner stage) and its audience. Usually, this "holographic" representation appears as a life-sized person to audience members in the auditorium. Overhead displays reference feedback streams for the presenter and the audience. As a spatial display technique, Pepper's Ghost serves as a platform for real time communication. In KIMA this platform is re-purposed, abstracted and used for non-photorealistic representations of presence. Sound particles convey presence within this holographic display environment.

A second conceptual layer is telepresence art. In line with technical developments and increasing importance of remote presence for people across the globe, the arts discussed remote presence in fields as varied as performance, video, sculpture or installation. Ken Goldberg's "Telegarden" (Goldberg 1995) in the mid-nineties or Eduardo Kac's "Ornitorrinco on the Moon" (Kac 1993). Raphael Lozano-Hemmer's telepresence installation for Ars Electronica "Displaced Emperor" (Lozano-Hemmer 1997) shifted the focus in telepresence to architectural environments. Performance groups like Ghislaine Boddington's Body/Data/Space have experimented with new forms of telepresence over the last decades. In theatre, the "English National" has found a new outlet in telepresence performances. Telepresence sculptures have manifested in multiple forms, ranging from Assocreation's "Bump (2010)" - which connects two remote location through a shared pneumatic floor interface- to Michael Takeo Magruder's "Data flower" (Takeo Magruder 2010) - a holographic sculpture based on a live internet stream. KIMA is at once a telepresence environment, a performative space, a sound installation and a holographic sculpture – a communication interface to experience spatial and visual qualities of sound.

On an academic level, KIMA scrutinizes how sound enhances telepresence experiences for individual users. Studies diverge on the question of whether immersive sound enhances presence effectively and if so to which degree. This setup presents audiences with an abstracted idea of presence, one that is entirely communicated through sound or sound representation. 2-dimensional sound is contrasted with spatial sound experiences. Immersive sound becomes a presence-defining element. In the juxtaposition between surround sound and 2-dimensional sound, this case study tries to find answers to their respective relevance and ultimately to the question if immersion and presence are interrelated. To this end, the physical setup is followed by an academic evaluation based on interviews and questionnaires. A pilot study preceded the actual case study, both phases were orchestrated through a triangulation of methods. The following chapter presents the case study KIMA, from an artistic and technical as well as research design.

7.3 KIMA - Case Study Protocol

A. KIMA - Case Study Overview

The objective of this case study is to analyse and exemplify the role of immersion. Specifically, this research investigates the role of immersive sound in the context of presence design on Pepper's ghost. Immersion is understood as a perceptual reality within a mediated environment, encompassing as many of the user's senses as possible. Following the proposed "Standard Telepresence Model" as analytical framework, immersion is understood as one of three co-factors of presence. This case study presents an immersive sound environment for telepresence that permits to actively observe the effect of immersion on telepresence and to monitor its effect in the context of my practice.

The intention of the case study is to explore the research question whether immersive sound affects the perception of presence positively. The case study is situated in the field of media art. Contextual references derive directly from the field of media art, specifically networked installations, audiovisual art forms and contemporary art practices tangential to research in cymatic patterns. The research concentrates on the role of sound in the generation of presence across networks. The mission of the commercial sponsor is to understand the effect of sound on presence better, so to sustainably augment presence experiences in future developments.

Inferred from the STM framework, the hypothesis is built on the assumption that immersion, conveyed through multi-dimensional sound environments, affects the perception of presence positively. The case study proposes a symbiotic link between immersive sound and presence experiences. Inversely, we can construct the null-hypothesis to falsify if surround sound fails to positively affect the perception of presence in a remote location.

The theoretical framework conceptualizes immersion as a physical, technical and perceptual condition. On a technical level we can differentiate between inclusive, extensive, surround and vivid cues of immersion (compare: Slater & Wilbur 1995). On a perceptual level, we can distinguish between social, attentative and temporal cues of immersion. The STM framework conceives immersion as a central component of telepresence, as a core constituting factor. Terms and concepts have been developed after critical readings of key findings on immersion including Oliver Grau (2003), Slater and Wibur (1995), Cairns et al. (2006). This case study applies this model, probes its validity and scrutinises the research proposition through a triangulation of methods. The case study protocol builds the framework for the implementation of data generation methods. The KIMA setup has been conducted in two tiers, making use of a mix of methods of quantitative instruments (survey, questionnaire) and qualitative methods (participant observation, focus group research and interviews).

B. Data Collection Procedures - Phase 1

This case study is conducted as a sequential mixed method analysis with a pilot study in a first, exploratory phase, followed by the actual case study - an intervention with a more explanatory objective. Both phases -pilot and case study- make use of a triangulation of methods. The pilot was conducted on the 30th of April 2013 at Musion HQ, Westcott House, as a live performance with the collective Analema Group. My role as producer consisted in planning of the project, technical organisation as well as practical execution. As researcher, I was in charge of designing the questionnaire, and organising the focus group research. The moderator of the focus group was Evgenia Emets, artistic director of Analema Group. My mentor Alain Renaud created the KIMA sound design. The first phase of the case study focused on a performative intervention, followed by a survey and a focus group.

The performance itself, designed over ten minutes, included a live improvisation by choreographer and dancer Anna Buonomo, joined by the voices of Lani Rocillo and Evgenia Emets. The performance was structured into two parts. The first was delivered with a stereo sound-scape, the second offered 4.1 surround sound. The pilot was designed to showcase telepresence, with both musical performers singing off-stage in a different room, and the dancer on-stage facing the audience. Sound was represented visually as cymatic pattern on the Pepper's ghost display. The dancer's movement modified cymatic patterns in real-time through motion-capture. Alain Renaud's immersive sound design built the acoustic framework to this multi-sensory telepresence. The piece was presented as timed performance to a select audience. It was the objective of this intervention, to probe the functionality of the interaction design so to investigate the hypothesis.

The audience was recruited from the field of Arts, academia, and media with a relatively even spread in gender. The founder and director of Kinetica Art Fair, a representative of Arts Council England and interested artists represented the Arts. Academia was represented through the director of the Masters of Arts program in animation at Central Saint Martins, Birgitta Hosea, as well as PHD students from Bournemouth University's Center for Digital Entertainment (CDE). The number of invitees totalled 15. Following the performance, a semi-structured survey was handed out, leading into a moderated focus group discussion. All attendees took part in the survey, followed up with the focus group discussion. No prior explanation was given after the performance, so not to influence any results. The focus group shed further light on the role of surround sound in the conveyance of presence.

C. Data Collection Questions – Pilot (Phase 1)

Data collection questions focused on the role of sound as conveyor of presence.

- A comparison pre-and post introduction of immersive sound on presence experiences
- The role of immersion in creating presence
- Dominance of sound or visuals during the performance
- Latency during the performance
- Future development of the work

The focus group concentrated on artistic, conceptual, technical and practical considerations of audience members. Focus group questions concerned possible improvements, readability and clarity of the installation, effectiveness of the visual form, the relationship between sound and vision and how to further accentuate their intrinsic physical connection with digital means.

Evaluation of the pilot case study was followed up on three distinctive layers:

- Survey results were compared and analysed.
- Analysis of focus group discourse
- Participant observation in the research team and implementation of suggested improvements prior to the second phase of the case study:
 - Overcoming latency as a hindrance to readability of the performance
 - Conceptual improvements linking the installation closer to the original brief
 - Improvement of the visual form as a key signifier of sound - vision relationship
 - Improving the methodology

Convergence of data acquired through a mix of methods enhanced construct validity. More importantly, the pilot provided conclusive results on technical and conceptual flaws in the research design and had a direct effect on the technical setup, the design of the case study as well as its evaluation methods.

Most notably, the scope of the questionnaire, its inability to differentiate thoroughly between concepts and the limits for the analysis of the data, led to an in-depth analysis of existing presence measurement methods. For the second phase, the decision subsequently fell on the Witmer & Singer questionnaire as de-facto standard in presence research

D. Guide for Case Study Report – Pilot (Phase 1)

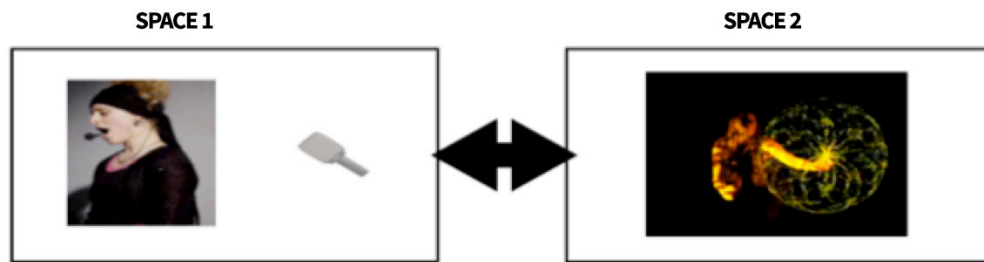
The performance was staged without any major technical difficulties and recorded for future documentation. As this was a pilot, the performance was characterised by minor technical flaws, as the focus group panel shows. The discussion pointed towards the need for technical improvements in key areas, such as latency of the visualization script, latency of the motion tracking software and a need for simplicity in the interpretation of sound properties. The focus group pointed to conceptual ambiguities resulting from the complexity of KIMA's visual representation. Consequently, simplified functionality was required to assure clarity of sound frequencies and their translation into colour patterns. The representation of two sound inputs was considered confusing and visually overwhelming. A narrative arch was missing for a dynamic performance.

Nevertheless, the pilot consisted in a breakthrough for the project. Opening a debate with the public, the collective was able to identify technical and conceptual shortcomings and to answer first exploratory questions of the research proposition. Summa summarum, the presentation led to a conceptual and visual reconsideration of the project: We reduced complexity of cymatic patterns and latency. Prior to the setup at the Festival of Learning, various other visual improvements were introduced such as attack to particle mapping, amplitude to extrusion mapping and an octave scheme. The pilot gave KIMA a platform to probe research strategies, and revealed shortcomings of the evaluation method: The survey itself showed a low construct validity. The terminology was vague and not well defined, which led to confusion among audience members. Taking this feedback into account, the second-phase relied on a validated research instrument with high construct validity. Despite conceptual deficits, the pilot illustrated a large consensus among audience members. Heterogeneity of focus group members ensured a lively and productive debate. The pilot answered exploratory questions, through an initial falsification process of the hypothesis. As formative research, the pilot laid the bricks and mortar for a more in-depth analysis during the second phase of the case study.

7.3 Technical Setup and Design – Pilot

The KIMA pilot offered a “one-to-many” solution to test the effectiveness of the installation by confronting the audience with a staged telepresence performance. Pepper's ghost combines stage and screen experiences in a classic theatrical environment. The holographic projection stage thereby acts as a virtual interface, creating an interface for live interactions between performer and virtual image for an audience. The relationship between audio and visual representation was accentuated and emphasised, to understand the influence of surround sound on telematic experiences. KIMA's design intrinsically couples the prevalence of sound to telepresence. As “*conditio sine qua non*”, sound engenders telepresence. Surround sound was compared directly to 2-dimensional sound.

Fig. 18: KIMA pilot research setup



As a networked telepresence installation, KIMA creates a real time representation of a sound scape from space 1 onto the holographic stage in space 2. Interaction with sound, leads to its visual modification. The interplay between telematic sound representation and visual feedback is evaluated while directionality and dimensionality of the sound scape changes. Throughout the performance, the directionality was altered from a 2-dimensional stereo sound, to a fully distributed sound design. Surround sound was introduced three minutes into the performance, accentuated throughout and culminated in a complete 5.1 surround sound scape for the last third of the performance. Here, the audience acted as a passive observer to the telepresence experience, attesting the influence of surround sound on the telematics experience in retrospect through a focus group panel discussion and a follow-up survey. Focus Groups allow for collective feedback and provide an analytical response tool particularly useful for exploratory studies (Fern 1982). In this case, the role of the audience was to attest the impact of sound and immersive sound on presence experience to validate the usefulness of further explanatory research in a second phase of the KIMA case study.

7.4 Case Study Report – Phase I

KIMA was presented to its audiences as “research in the wild” (compare: Benford 2011, p.11). The panel of the focus group was recruited from experts in the field of media arts in the UK and included a representative of major art university (UAL), media university (Bournemouth University) as well as art institutions (Arts Council UK, Director of Kinetica Art Fair), artists (Old Vic, et al.) and students. The analytical framework informed the pilot’s research. Both focus group and survey addressed the effect of immersion and interactivity on presence. The focus group was conducted as a moderated, but open Q&A session. Audience members had no prior conception of the nature of the event, the technical setup, the performances itself or the type of network. The majority of participants had experienced holographic effects on Pepper’s ghost, but was new to telepresence in this context. Multi-dimensional sound was introduced unobtrusively to ensure users remained unprepared. The survey was handed out immediately after the

performance, so not to distract, influence or divert attention. The questionnaire was followed up with a moderated focus group panel discussion and the session was concluded with a debrief, summarising observations of the pilot test. As observers, the audience was the key subject of telepresence, as PG-facilitated telepresence exclusively addresses the audience itself as the one participant exposed to the illusion of Pepper's ghost, ergo the one party experiencing telepresence visually.

7.5 KIMA - Subjects

The pilot was presented purely for research purposes to an audience of industry experts and academics. The audience was invited through the British Computer and Arts Society and recruited from the field of media, arts and academia to allow for an informed discussion of the terms. The intervention, a 10-minute performance, was followed up with a survey, a focus group session as well as questions on personal experiences and potential improvements. All questionnaires were filled out anonymously. 15 subjects provided feedback with a distribution of 6 female and 9 male attendants.

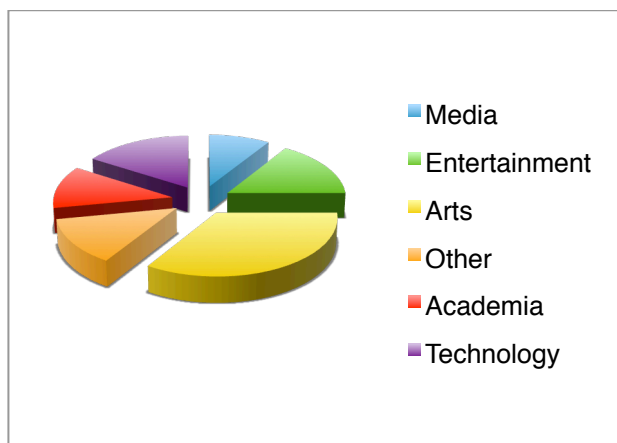


Fig. 19: Graphs - Expert panel statistics

7.6 Results - Pilot

The vast majority of industry experts perceived sound as very contributive to presence: 60% answered the question positively, attesting an inherent correlation between sound and presence, with a further third viewing sound as conducive to presence experiences. Visuals created on the holographic screen device were generated in real time, with higher frequencies creating more complex shapes. Regardless of the specificity of the setup, the hypothesis that sound does have a part to play in creating presence experiences, has been strongly supported by the expert panel. In a second step, we tested the dominance of sound over vision to ascertain whether a hierarchy in presence co-factors can be attested.

Our audience showed a relatively even distribution, asserting the dominance of sound over vision in this specific research setup. A third of all participants found that interactivity

transcended through sound and visuals in equal parts, with the rest of the interviewees almost equally divided in their account. Although these assertions are setup specific, they illustrate that telepresence interfaces can convey balanced, multi-sensory experiences and are not exclusively reliant visual image representation.

7.6.2 Research Design

We further asked if the intrinsic relationship between sound and visuals was apparent in the KIMA setup? The vast majority (80%) perceived sound and visuals as connected – pointing to the successful real-time functionality of the setup. On a technical level, the KIMA installation followed the conceptual brief, extrapolating the fundamental relationship between sound and vision.

The independent variable in this pilot was immersive sound and its contribution to perceptions of immersions. 60 % of all attendants considered sound as very contributive to the immersive experience with a further 30 % regarding sound as a contributive factor. A total of 90% of our expert panel attested a positive correlation between sound and presence. 43 % of interviewees considered surround sound as very important factor in the creation of presence, another 36% found surround sound to be a contributing factor. An overall sum of 80% of all respondents acknowledged the role of surround sound in the creation of presence. This contestation was astonishing as surround sound was employed with subtlety. Summa summarum, the pilot confirmed the key role surround sound plays in the design of telepresence on a fundamental, exploratory level.

7.7 Comparing immersive sound to 2-dimensional sound

The declared aim of the KIMA pilot was to decouple sound from vision so to investigate the multi-sensory character of presence. Our research setup conceptualised sound as an independent variable in the creation of presence, as “*conditio sine qua non*” - a constituent of presence. Regenbrecht, Schubert and Friedman (1998) reasoned that presence can be a function of, but is not limited to photorealistic representation. Presence can be evoked through its underlying co-factors, whether in abstracted or representational form. In Kima, an abstracted representation highlighted the intrinsic relationship between sound and vision. Our research setup allowed for direct communication between two distinctive places through the translation of sound and movement into a visual representation. The contrast of sound and vision triggered a discussion on dominance of senses and on the role of immersive sound as cue factor for immersion.

A number of studies compared purely visual presence to sound supported presence experiences: Storms (1998) as well as Lessiter & Freeman (2001) showed a positive link between sound and presence experiences. In this context, Snow (1996) measured the effect of sound cues on 32 students and attested a significant positive link for sound cues on presence experiences. In a study with 322 undergraduates Dinh (1999) established a positive correlation between sound and presence experiences. Interestingly, Welch (1999) confirmed the relevance of sound for presence experience, but showed that sound had no effect on task performance. Research by Murray, Arnold and Thornton (2000) and Gilkey and Weissenberger (1995) on presence experiences and hearing loss emphasises the importance of sound for presence experience. Recent research by Louise Fryer, Linda Pring, and Jonathan Freeman (2013) at Goldsmith University has highlighted the immersive qualities of sound and its contribution to feelings of presence by looking at different levels of sound and sound effect receptivity for people with impaired or no sight. Riecke (2009) proved that moving sound stimuli (as opposed to just multi-dimensional sound) contributed to presence.

In its first iteration as pilot, KIMA illustrated the role of sound in presence design. The holographic screen allows for new forms of sonic telepresence merging physical realities with virtual realities. Remote presence relies on a number of different cues, sound fidelity being one of them. As McKinley & Ericson (1997) pointed out that human spatial sound perception is limited to an accuracy of between 5-10 degrees. Providing a sensitive sound environment has is constrained by human ability to locate sound attenuation. Yet regardless of accuracy in sound spatialisation, the prevalence of surround sound seems to affect the perception of presence. The pilot's results indicate a positive link between presence and surround sound. A vast majority of participants (79%) reported a strong correlation between surround sound and presence experiences. KIMA demonstrated an infrastructure for non-verbal, non-representational presence that was able to establish sound and vision as distinctive, dichotomous yet interrelated, co-factors of the same phenomenon. Both within the survey and the focus group discussion, expert opinion confirmed the relevance of sound for remote presence, with 90% of participants regarding sound as a contributive factor to their experience in the survey. KIMA was designed to compare 2d sound against immersive soundscapes. Surrounding the user from all sides, sound can help to understand the fundamental relationship between presence and immersion. In KIMA, sound plays the role of a common denominator. Without sound input, visual form is not represented in the remote location, the flow of communication thus interrupted. Here, sound is not merely a component of, but requirement for presence. Sound becomes a *conditio-sine qua non*, as without it the experience of presence is rendered impossible. A majority of survey participants reported a strong relationship between surround sound and presence. The focus group provided further indicators to support this hypothesis.

7.8 Focus Group Research & Observation

Focus Groups panels are seen as both contextual and relatively non-hierarchical method (Litolesiti 2003). They allow for a direct feedback towards an artefact - in this case the KIMA setup. An open discussion addresses key issues of technical, conceptual and perceptive nature. Often used in preliminary, exploratory stages of a research design, focus groups help to assess the status quo as much as they help to define key areas of future research and development.

In this case study, the focus group provided a forum for expert discussion on the role of sound in telepresence design. Recruited from neighbouring fields, the group provided the research with valuable input that could only really be provided by experts and an audience familiar with the subject matter. Focus group research led to a discourse on functionality and conceptual ambiguities of immersion on Pepper's ghost. Moderated by Evgenia Emets, creative director of Analema Group, the discussion shifted quickly towards the role of sound as a presence conveying factor, differences between immersive sound and 2-dimensional sound and the usefulness of multi-dimensional sound in complex mediated environments. The final segment of the discussion focused on future development. The focus group consisted of a relatively even spread strata of men and women, dominated marginally by women in a 60:40 ratio. Four participants were between 40 and 50, 6 between 30 and 40 and 5 were between 20 and 30.

Regardless, degrees of familiarity and expertise in real-time interaction and telepresence differed from participant to participant. The tenor of the group concurred on importance of sound in presence experiences. Initial feedback showed that complex interaction was perceived as confusing. More than one sound representation resulted in conflicting visual signals. During the pilot, Analema Group used a sphere to represent cymatic patterns. Projecting two voice patterns onto a single, discreet, shape for two sound inputs, made it difficult to interpret which sound signal correlated with which pattern. Latency was perceived as obtrusive factor and inaccuracy in motion capture was perceived confusing. Audience feedback led to an overhaul of the script. Focus group feedback acted as eye opener, pointing towards redundancies in performance and its staging. An open debate clarified, where further conceptual and visual development was required. The focus group revealed the limiting nature of an exploratory study: Audience members disagreed on conceptions of terminology used in the questionnaire. Furthermore, not all focus group panelists were familiar with networked performances. As panel size and scope were limiting, the pilot led to a reconsideration of the research design for the second phase of the case study.

During the second phase, the audience became an active participant, within a fully interactive installation at Bournemouth University's Festival of Learning. The research design was adapted to reflect a more systematic approach: Evaluating presence experiences using a dedicated Presence Questionnaire - the Witmer & Singer questionnaire assured higher construct validity, capturing the multidimensional subject nature better. Feedback from the panel led to a slicker interaction design and a more complex evaluation method. The triangulation of focus group data, survey and observation yielded enough conclusive results to indicate the prevalence of a relationship between immersive sound and an augmented presence experience.

7.9 Summary Pilot Study - Sound and Immersion

Research on sound and presence remains fragmented and incoherent, and stands only at the beginning (Bracken 2010). Lessiter and Freeman (2001, p.234) showed that the introduction of bass frequencies significantly enhances presence experiences - specifically spatial presence is affected by audio-visual properties of sound. The pilot points in the same direction. Presence is increasingly understood as a multi-dimensional phenomenon with sound as key component for an all-encompassing experience. In the Arts, pioneers such as Pauline Oliveiros have conducted extensive experiments with sonic telepresence at her Deep Listening Institute since the 1980s. In Montreal and Poitiers (France), Yann Breuleux and Robin Meier (2012) have created immersive sonic telepresence installations. Garnier, Henrich & Dubois (2010) analysed sonic immersion in its most extreme form in the concentration on communicational practices and subconscious implications in the context of the Lombard effect, the propensity of speakers to increase their vocal impact in loud environments. Research in immersive sound is credited with more and more relevance in gaming design (Grimshaw 2011). The complex relationship between sound and presence has been discussed in a multitude of studies (see: Bracken 2010). Future research has to dissect the relationship between sound and vision more deeply.

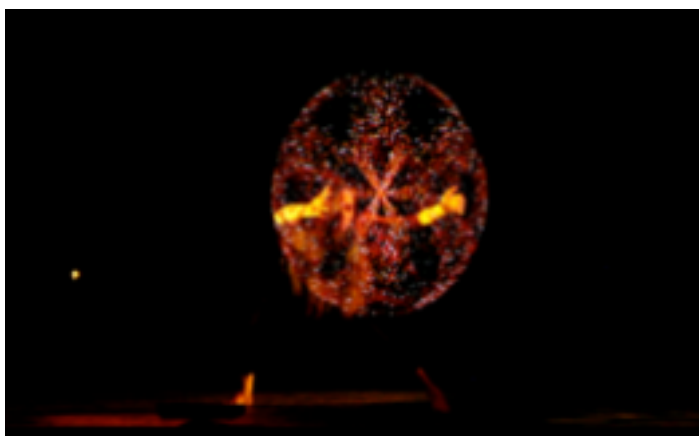


Fig. 20: KIMA with Anna Buonomo at Musion, Westcott House, Portland Place

Evaluation of focus group and survey responses in the KIMA pilot setup were consistent with research in the field. An overwhelmingly majority of 70% of panelists confirmed a perceived co-dependency between immersive sound and presence. Consensually, panelists attributed an elemental role to immersive sound in generating remote presence. Questions persist: By decoupling sound from vision, could the design of the KIMA pilot have biased and slanted research results? Were respondents merely stating the obvious? Yet, the focus group could have yielded completely different results. Controlling for confounding variables of presence, the intervention posed fundamental exploratory questions: Is immersion a constituting factor of presence? Are immersive sound experiences intrinsically linked to their display medium as research by Bracken (2010) suggests? Or does immersive sound distract from visual cues as research by Borman (2005) proposes? In contrast to research by Lessiter & Freeman (2001), focus group results clearly point to a positive correlation between immersive sound and presence. This result contradicts the idea of a “self-fulfilling prophecy”. Had focus group panelists been unable to detect a link between presence and immersive sound, any prevalence of a relationship between the two would be questionable. Results of the pilot suggest a positive relationship between presence and immersion. Despite its focus on exploratory questions, the KIMA pilot was characterised by relatively low construct validity: Moderators were heavily engaged in art practice and collaborative processes. Focus group panelists were familiar with one another, and with the subject matter of Pepper’s ghost, telepresence and/ or audiovisual performance art. Consequentially, bias might have influenced them partially. Secondly, the survey lacked a clear definition of terminology and can be seen as simplistic. However, the format of the intervention assured audience’s awareness of the role of sound in presence experiences. This case study focused exclusively on immersion – eclipsing and thus controlling for realism and interactivity as co-factors of presence.

Despite such criticism, the pilot answered fundamental exploratory questions. Following the logic of pattern matching (Trochim 1989), the pilot produced congruent empirical results to the predicted assumption that immersive sound is directly related to presence experiences. Converging research data from the survey, a focus group and participant observation (interview transcript attached in the appendix) - immersion and immersive sound appeared to be directly linked to telepresence. A number of empirical indicators provided by both focus group and survey reaffirmed this relationship, yet poor construct validity of the questionnaire led to its review prior to the second phase of the case study. Using dedicated research instruments with a higher reliability and higher construct validity, the second combined participant observation, a survey and an experiment with the Witmer & Singer presence questionnaire.

7.10 KIMA Case Study Protocol - Phase 2

A) Case Study Overview

If the KIMA pilot explored the prevalence of a link between immersion and presence, the second phase of the case study, concentrated on its significance and effect. Key questions of the pilot had remained unanswered: How and why is immersion contributing to presence? Which underlying factors determine its effectivity? The second phase, proposes an intervention to examine the relationship between sound and vision more closely. A set of instruments (presence questionnaire, observation, interview) analyses sound as an inhibitor and constructor of immersion - as an invisible force that takes the audience into its center. The Witmer & Singer presence questionnaire evaluates the phenomenon of presence across seven different dimensions: realism, interaction quality, self-evaluation, sound and touch. The KIMA case study tested these dimensions using immersive sound as single, determining presence constructor with my own creative practice as the objective of study.

Surround sound encompasses our senses, enabling the interactant to perceive sound from within a mediated experience. The link between immersive sound and presence is all but clear: Studies by Lessiter & Freeman (2001), point to a non-significant link between surround sound and presence. Conversely, Hendrix and Barfield's findings (1996) show a significant effect of spatialised sound for presence. The industrial mission is to demonstrate if immersive sound affects presence, with the intention to augment presence experiences in future applications. The KIMA case study follows the hypothesis that immersion and its underlying technical and perceptual cues -as defined in the STM framework- can be related to presence experiences in the context of my creative practice. The role of the research protocol is to structure the line of inquiry through a standardised agenda.



Fig. 21: KIMA at the ICT 2014 with Satoko Fukuda

B) Data Collection Procedure – Phase 2

The second phase of the KIMA case study was presented at Bournemouth University's Festival of Learning from the 9th to the 14th of June 2014. Following technical and conceptual feedback, the piece was redeveloped substantially with a series of modifications and conceptual considerations. The art collective Analema Group, i.e. myself in my role as its producer and the programmer Joe Pochciol installed the piece as a stand-alone participant installation. In this mode, KIMA was setup across two spaces, for users to actively and interactively explore the translation from sound to vision. The presence questionnaire, the key evaluation tool, was administered by the CDE - Center for Digital Entertainment and its assistant Diana Idris via ipads. An online version of the presence questionnaire had been tailored to suit the study and was available via QR code to our audience.

The visual component of KIMA was presented within a pyramidal holographic projection at eye-level in one room. As a free-floating holographic sculpture, participants modulated soundwaves in real-time through sound input in one and kinectic interaction in a second space. In both spaces, participants were presented with an immersive sound setup: A headset was made available in space A featuring the visual interface, and a 5.1 surround sound setup served as sound interface in space B. Sound travelled freely between the two spaces. A complimenting sound scape designed by Dr. Alain Renaud interpreted movement of participants in space B, relaying sound in real-time to space A - both sonically and visually. Users communicated with one another through a microphone in space A as well as through movement modulating sound input in space B.

A data collection plan guaranteed the successful evaluation of the presence questionnaire. 280 visitors to the Festival of Learning consisted mainly of students, the general public and academics from the university. The presence questionnaire was marginally adapted to reflect the nature of KIMA at the University. Posters and a brief by the invigilator ensured participants were prompted to participate in the survey. QR codes with links to the questionnaire were presented on posters around the venue. However, only a limited number of people, eleven in total, completed the questionnaire in full. The relatively low turnout can be attributed to the complexity of the Witmer & Singer questionnaire and the time required for its completion.

C) Data Collection Questions

The KIMA-case study investigates the effect of immersive sound on presence experiences. The Witmer & Singer presence questionnaire was prepared using an online survey (surveyplanet). The allocation of a QR code for mobile phone users facilitated

mobility. The setup itself was designed in a more elaborate and sophisticated manner than during the pilot. The installation consisted of a commercially manufactured holographic pyramid installation in space A, which enabled users to view the holographic sound visualisation on a Peppers ghost display from three sides. This space A conceptualized as the primary, visual space, was equipped with a microphone input in front of the pyramid for real time visualisation and a set of headphones for an immersive sound experience. The second space B, connected to the first one through a staircase, was equipped with a 4.1 surround sound speaker system, a motion control camera and a second microphone. Users in space A were affecting mathematically meaningful, visual representation of sound waves in real-time through the microphone input. Users in space B were experiencing sound as an immersive installation, and were able to control and manipulate that same sound scape through their movements. The conceptual implementation of the installation was closely tied to initial publications in MIT Leonardo Journal, the EVA Conference and the Siggraph Art Papers presentation to ensure conceptual integrity. The idea was to provide participants with a dual representation of sound. In the immersive sound environment, the body becomes an instrument, as participants effectively turned into dancers and musicians. In space A, sound is experienced visually on the holographic display using Peppers ghost technology.

With the KIMA case study, the user moved to the center of the piece: As soon as participants create sound, they generate wave patterns within the holographic setup in space A. In space B, movement inside the sound chamber results in an immersive sound structure. The interplay between two spaces creates a joint telepresence experience with sound as sole mediator. Users of KIMA were experiencing sound as reactive environment of visual qualities. In the reduction of telepresence to a sound sculpture, the role of sound as conveyor, transmitter and fundamental constructor of presence was emphasized. Successful funding assured complexities in sound visualisation were represented to the highest standards. Learning from the pilot, mapping of colours to specific frequencies resulted in strictly coordinated colour palettes, a representation of tones as specific frequency bands on the visual display. The inclusion of a third dimension of cymatic patterns generated a new layer of complexity: Extrusion along the X-axis now signified sound peaks. Attack values of sound were correlated to pixel movement and their latency. The installation was carefully tuned resulting in a coherent and meaningful audiovisual experience.

The high profile of the event (BBC news, official visit by a government representative) assured that a large number of visitors - 280 active users - participated in the experience, creating collateral data for participant observation. The choice of survey, the Witmer & Singer presence questionnaire guaranteed internal and external validity by assuring inter-compatibility with other studies. However, time ramifications and intricacies of such a

complex questionnaire resulted in a relatively low turnout of survey participants. In a triangulation of methods, the presence questionnaire was accompanied by participant observation throughout the installation as well as interviews, questioning the role of immersive sound in the creation of presence experiences.

The KIMA case study can be regarded as successful in exemplifying the role of immersion in telepresence experiences. Offering a new telepresence interface, KIMA illustrated the role of sound in the creation of presence across a distance. The installation was sponsored by the Arts Council England and the CDE - Center for Digital Entertainment.

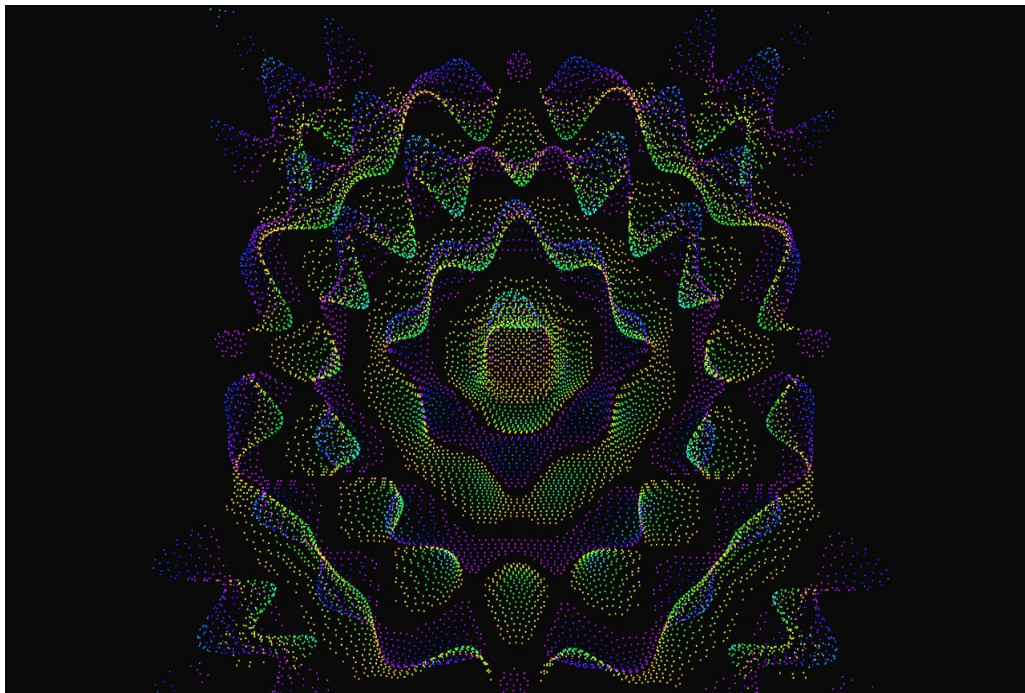


Fig. 22: KIMA as presented at the Festival of Learning 2014

D) Guide for Case Study Report – Phase 2

The audience of the KIMA case study report are academics and researchers in the field of presence research, applied and theoretic media scholars, artists and art theorists, all those interested in the augmentation of presence experiences in commercial applications including networked environments, communication technologies or integrated media experience providers. Users explore the relevance of sound in telepresence interactively, and by playing, improvising and creating a sound environment, learn how to understand not only principle components of sound, but its central functionality as a communicative tool across spaces Immersive sound is presented as key constituent and co-factors of telepresence in the context of my creative practice.

In KIMA, sound acts as a real-time engine for sonic representation: Sound is evoked as visual representation on the one hand side, and as a kinetic, bodily phenomenon on the other side. The multi-faceted nature of the installation creates a user interface for dancers, performers, musicians, and the public. The setup is intuitive so that sound can be experienced as a telepresence transmitter without further explanation. KIMA presents an infrastructure for communication, across spaces, across disciplines, across senses. KIMA has been installed at Kinetica Art Fair during Art Fair week with 10,000 visitors across four days. Subsequently, KIMA was presented at the Includoo Festival for the hearing impaired, offering alternate sound experiences to new communities. Last but not least, KIMA was presented at Union Chapel in March 2015 and the Roundhouse London in August 2016 transforming sound into an architectural, spatial environment for live performance. This case study report presents the 4 day-long installation of KIMA at the Festival of Learning.

KIMA builds a unique framework for the exploration of sound as a telepresence instrument. The piece discusses visual properties of sound in the tradition of synaesthetic art of Gruenewalt, Kandinsky and Whitney. As research contribution, KIMA helps to highlight how immersion affects presence through underlying factors as enumerated by Wilbur and Slater (1995). KIMA offers a descriptive, explanatory case study, which discusses applications of a theoretical model - the STM framework - within the context of my creative practice through a mix of methods: a survey, observation and interviews. Visual documentation of the KIMA installation at the Festival of Learning is part of supplementary documents of this thesis. Interview with Analema Group's artistic director and the evaluation of the Witmer and Singer Presence Questionnaire form part of the appendix.

7.10 KIMA - Case Study Report – Phase 2

For the purpose of the intervention at the Festival of Learning, the KIMA case study was presented as an interactive art installation, rather than a performance. Individual users engaged with the piece, experiencing presence through sound interactively. As a standalone installation, the setup had to meet certain requirements: The piece had to be intuitive to use and easy to engage with. A 5.1 surround sound system and a motion capture device (kinect) in one room invited users to use their body as music instrument, added microphone input further enhanced the sound scape and interaction possibilities. In a separate room, users saw a visual interpretation of this sound scape in-real time, influence its shape through a second microphone input. The setup deliberately emphasised the role of sound in remote communication between spaces. The hypothesis postulates a statistically significant relationship between immersive sound and presence

as proposed by the STM framework in the context of my creative practice. A triangulation of methods focused on the evaluation through a quantitative study (survey), observation and interviews. Mixed methods guaranteed inter-comparability of results, assured a critical analysis of numerical data, despite relatively small sample numbers. The third method, an expert interview with the artistic director of Analema Group, Evgenia Emets can be found in the appendix

Through inference, we can build a hypothesis stating a significant relationship between immersive sound and presence. Mutually exclusive to the hypothesis as well as exhaustive, the null hypothesis assumes no significant relationship between immersive sound and presence. Comparing the functionality of the KIMA setup to other virtual environments with a large degree of presence, we can evaluate the effectiveness of immersive sound for presence experiences. The KIMA setup probed the null-hypothesis with the help of the Witmer and Singer presence questionnaire in a one shot case study.

The UQO presence score is an international standard for high impact virtual environments. Comparing the UQO presence norm to KIMA, differences or similarities become apparent. If immersive sound, as transmitter for presence in KIMA yields comparable presence scores to other VEs, we can conclude that immersive sound acts as a co-factor of presence with a certain degree of statistic probability. The study investigates the relationship between presence as dependent variable and immersive sound as the independent variable. This one shot study was conducted as a quasi-experiment with a convenience sample of 11 subjects, and Cronbach alpha of 0.67. The study's results were statistically compared against the population norm in a Z-score analysis. Subsequently, the study's findings were triangulated with other research data such as participant observation and interviews, to contrast purely quantitative data with qualitative research outcome.

7.11. Subjects – Phase 2

The Festival of Learning at Bournemouth University addresses all 12,000 students in a week of exams at the end of the academic year: A series of lectures opens the university campus not only to students, but also to the wider public. 3100 tickets were sold on top of free events, installations, and performances open to students, academics and the general public. KIMA was presented within the context of media art, door to door with the university's interactive art and design program degree show. The presentation was accompanied by an evaluation protocol, conducted according to strict academic standards, to avoid researcher bias and to assure a degree of inner construct validity.

Conceptually, the presentation at the Festival of Learning was as close to the original model of KIMA as presented at Siggraph, in the Leonardo Journal and at the EVA conference: KIMA was staged as a user installation in two spaces. A sound sculpture was visualised on a holographic display in one space. A 5.1 sound installation was combined with motion tracking in an immersive sound sculpture in a second room. The two spaces were connected via a network with very low latency. Audience feedback was gathered through participant observation and the Witmer & Singer presence questionnaire.

Feedback from previous iterations was taken into account during development of the piece. The installation presented the audience with very low latency. The visual interface demonstrated interference patterns of sound across two spaces. In addition, motion tracking resulted in an interactive sound sculpture designed by Dr. Alain Renaud. Uptake and level of engagement proved the success of the installation in playfully explaining an inherent link between sound and vision.

Audiences were invited to habitually explore freedom and constraint (Compare: Candy 2007). After the pilot, the team had simplified the complexity of the installation. Designing the experience of the evaluation (MacDonald, Cockton et al. 2006, Isbister et al. 2006) was the key agenda during this development phase. The Witmer and Singer presence questionnaire uses 25 questions to gain in-depth knowledge into presence experiences. This structured questionnaire was offered to the audiences on Ipad's or via a web interface accessible through QR code. Despite an uptake of over 280 visitors actively engaging with the installation for at least 5 minutes each, audience feedback remained limited. Six males and five females between 20 and 40 years completed the Witmer & Singer PQ. With over 20 questions, the complexity of the Witmer & Singer questionnaire contributed to the relatively small sample turnout.

An independent invigilator administered all questionnaires to avoid researcher bias. This assured that research results remained undistorted and helped in obtaining reliable and representative data. The analysis of the audience evaluation shows that KIMA was developed successfully: Little delay was experienced by 73% of all participants, 91% attested to perceive KIMA from different view-points. Localisation of sound was well developed, and visual impact was perceived positively for the vast majority of our visitors. 81% of audience members were intrigued to see KIMA again as a performance piece. The presence questionnaire provided not only insight into effectiveness of the installation, but quantifies the degree of presence achieved through immersive sound as mediating factor. The evaluation of the Witmer & Singer presence questionnaire was flanked by qualitative research - participant observation and expert interviews.

7.12. Participant Observation – Phase 2

As research method, participant observation stands in the tradition of qualitative, interpretative theories. Deriving theoretic constructs from observation, field research and social context, participant observation relies on an active role of the researcher in the generation of research data. In its “logic of discovery” (Kaplan 1964), researchers set out to instigate concepts, and generalisations, rather than hypothesis testing. The process of generating theoretical constructs from observation is regarded as a more flexible, open-ended and descriptive approach (Jorgensen 1989).

Participant observations have frequently been used in case studies (Compare: Becker 1968, Gans 1962), always with the aim to use the method to describe a phenomenon exhaustively and comprehensively. The role of the participant is always emphasized as a crucial factor in data finding. Data is generated by an insider within a field through techniques of introspection, field research or sympathetic reconstruction (MacIver 1942). The role of an insider can be assumed either overtly or covertly, depending on the specific context of the case. A certain degree of personal involvement by the researcher, an attitude of pro-active involvement is required for successful data mining. Methods employed can range from “direct observation”, in-depth interviews, questionnaires (like in this case) as well as secondary information such as videos or other documentation. The researcher is not necessarily obliged to disclose the intention of fact finding to his subjects. The condition of anonymity can contribute to construct validity, depending on the case. Participant observation makes use of various methods of inductive theory generation, as opposed to deductive approaches. Analytic induction provides a tool to arrive at theoretic constructs through a focus on core components of a concept. Analytic induction was first introduced by Znaniecki (1934), and is based on the principle of abstraction, instead of quantification. The process of analytic induction follows four fundamental steps:

- Outlining concepts, determining facts and concepts
- Abstraction, assuming that more general concepts can be observed in a larger quantity
- Researching classes containing these forms
- Organizing these classes into a system

The use of these very simple steps helps to align participant observation with the analytical model developed for this research – the STM framework. Analytic induction is based on the idea of generalization of key concepts. Key components of a system are explained in either a causal, functional or genetic way. Genetic explanations are concerned with the origins of a system. Functional explanations are concerned with the

relationship, dependences and independences of key components; Causal generalizations are dealing with ideas of cause and effect. These groups of abstraction help to explain a system and its key components, and ultimately a theoretical construct. Researchers applied analytic induction over generations (Angell 1936, Lindesmith 1947).

The definition of key concepts itself is extremely important in the process of direct observation. In this specific context the concepts of presence and immersive sound were key attributes to be measured and observed. Both concepts had been defined in the STM framework, and are further segmented into five different corollary components. The method of direct observation provides a set of research instruments to investigate user reaction to immersive sound beyond quantitative instruments. Participant observation provides interpretative, descriptive explanatory models that become particularly helpful when combined and triangulated with data analysis of the Witmer & Singer Presence questionnaire. The seven key areas that were investigated in the context of immersion as a co-factor of presence were four technical factors - inclusive cues, extensive cues, surrounding cues and vivid cues – as well as three perceptual factors – social cues, attention and temporal cues. Participant observation, focusing on these seven components or classes, resulted in conclusions on relationships between sound, environment, temporal factors and social factors.

Participant observation took place over four consecutive days at the Festival of Learning at Bournemouth University 2013. Questions were concerned with factors contributing to immersion - intervening variables influencing the effect of immersion on presence. Immersion, as a perceptual condition, relies on a multitude of factors to come into effect: Immersion not only requires visual encompassment by a technology or the exclusion of external audiovisual factors. Immersion is both a technical and a perceptual condition that can be more or less effective in its impact. The STM framework conceptualizes immersion as an integral component of presence. The definition provided by the STM framework is not an operational one, yet singles out key attributes of immersion for further analysis. These factors can be grouped into technical and perceptive cues:

The STM framework distinguishes between four technical cues: inclusive, extensive, vivid and surrounding cues:

Inclusive cues: Inclusive cues describe factors that literally enwrap the user in its center, such as darkened lighting, closed spaces etc. In the context of KIMA immersive sound, these immersive cues are characteristic of the fact that both spaces were separated, and reasonably self-enclosed: The location of the visual interface in an alcove meant that users were immersed into the architectural confinements of the space as soon as they entered. The location of the auditory space on a half-level between two floors meant

users were relatively shielded from passers-by. Participant observation was the method of choice to understand if and how inclusive cues contributed to presence experiences.

Extensive cues: It is the intention of extensive cues to enhance the perception of immersion by extending spatial perception – in this case through visual depth cues to create an optical illusion of 3D. In the context of KIMA, we used a Pepper's ghost display to increase depth perception. Participant observation was used to gain further insight into how users responded to extensive cues used within the context of the case study.

Surrounding cues: The use of headphones in the visual space on the one, and the utilisation of 5.1 speakers in the sonic space on the other hand, physically surrounded participants within a sonic experience. Both cues are inclusive in that the intention is to literally enwrap the participant within a sonic environment.

Vivid cues: In the visual space, vivid cues concentrated on a real-time colour and wave form interpretation. Vividness, flexibility and dynamic of the visual form, contributed to the immersive experience on a high-resolution 3D display. In the auditive space, a dedicated audio design by the artist Dr. Alain Renaud generated vivid cues. Participant observation was used to further understand if and how vivid cues contributed to presence experiences. A second group of cues is concerned with the impact of perceptual and social factors on presence perception.

Social cues: familiarity with subject can positively affect PG telepresence as research into parasocial relationships and social telepresence indicates (see Biocca, Harms, & Burgoon, 2003). In the case of the KIMA case study, participant observation helped to determine if and how social factors played a role.

Attention: The attention span of individual users depends on a plethora of underlying factors such as time constraints, interest, time of the day etc. Participant observation helped to determine if and how attention played a role in creating impact through immersion within the KIMA installation.

Temporal Cues: Research has shown that time plays a crucial role in creating presence experiences: A controlled experience with a defined beginning and end has a different effect on users than an ongoing installation without pre-determined timeframe. Equally, latency could play a factor in presence perception. Participant observation was employed to further investigate the role of time in the context of immersive sound telepresence.

At the Festival of Learning, KIMA was invigilated by an independent administrator to assure that the results would not be biased through the research team, and to maintain inner and construct validity. Participants entering the space were invited to try the installation, to use the microphone and to communicate with the second space in real time. Participants experienced the results of their interaction on the holographic display and as an immersive sound installation through headphones. User's reaction was protocolled. Additionally, participants were subsequently invited to explore the secondary space and to fill out the presence questionnaire.

The reaction of the users differed significantly from age to age, and from their propensity to interact across a distance. Even without another person present, the secondary space would record environmental noises from its immediate vicinity. Users were invited to playfully explore the two installations and to leave their feedback on the effect of sound on their experience.

Sound was singled out as facilitator, conditional prerequisite for telepresence: Without sound input from the secondary space, the experience was unable to translate into the same visual complexity as through telepresence. The effect on audience relied dramatically on the audience's eagerness to participate, on their sensibility and their propensity to make use of the microphones by generating sounds.

Technical factors influenced participants' behavior as much as social and perceptual factors: On a technical level, the space, which showed a higher level of inclusion seemed to be used more frequently. The alcove, in which the visual interface was placed, provided users with a sheltered environment, which assured a private nature to their interaction. In contrast, the second, more sonic space was kept more open. Users seemed to be more prone to interact in the first space, and to overcome initial reservations of microphone use quicker.

As extensive cue, the holographic Pepper's ghost display provided participants with a 3-dimensional display environment, which can be perceived from three sides. Being able to move freely around the pyramid and to be able to perceive sound not only visually but also spatially created a 3-dimensional focus point for the audience that attracted a lot of attention. Through an opening in the alcove, audiences were able to perceive the installation from afar and were almost magnetically drawn to it. Representing sound waves on a 3-dimensional plate within 3-dimensional space, the audience's experience was elevated from a screen-based experience into a spatial environment.

As surrounding cue, both spaces provided the user with an immersive sound

environment: Whereas the second space was equipped with 5.1 sound distributions, the first, more visual space provided headphones. Although the first space can be seen as more inclusive, the second provided users with a spatial sound environment. Both uses of immersive sound seem to have had a positive effect on user experiences as the evaluation of the Witmer & Singer questionnaire indicates.

Vivid cues were designed to draw the audience into the space and to involve them as much as possible. The responsiveness of the visual script, assured low latency as well as a high degree of visual dynamic. Secondly, sound frequencies translated immediately across the two spaces. Thirdly, vibrant colour frequency mapping, linked sound frequencies to a colour frequency spectrum. A dedicated colour palette was codified to represent octaves. The evaluation of the Witmer and Singer questionnaire points to a high level of engagement of audience members. Additional technical factors played a role in facilitating an immersive experience for the audience. A higher microphone position seemed to be perceived as more threatening and more intimidating. Once the position of the microphone was changed, initial shyness in using the microphone was noticeably reduced. Secondly, the presence of the invigilator facilitated an introduction to the installation. This helped to overcome technophobia, self-consciousness or shyness of audience members. The fact that a fully briefed assistant explained KIMA's functionality, and actively invited the audience to take part, removed a barrier to entry for many users.

In addition to technical factors, a number of social factors played a role in assuring the success of the installation. Participants familiar with the use of their voice were more inclined to be actively involved in the piece. Correspondingly, users with a strong interest in interactive art overcame initial shyness facing the microphone quicker. The attention span of the audience predetermined their propensity to interact: Mood and personal interest of an individual user largely influenced their respective level of involvement. In addition to time constraints, users with a relaxed attitude or an active interest in interactive arts were more likely to spend time with the installation. Last but not least, temporal factors such as low latency and immediacy of sound transmission guaranteed the success of the setup. Due to low latency and instantaneous reaction time of the installation, KIMA was intuitive to use. Audience feedback was predominantly positive with regards to perceived telepresence, as well as visual representation, an observation that was reinforced by the results of the Witmer & Singer questionnaire.

Summarising, it can be concluded that a number of key factors come into play when discussing immersion in the context of presence. A variety of technical and perceptual cues influence how audience members interact across a distance: While a secluded environment seems to facilitate the engagement (inclusive cues), it can also be perceived as a barrier to entry. 3D sound was matched by 3D visual representation, extending the

experience across various dimensions. This condition seems to have facilitated emotional engagement with the installation (extensive cues). Physical encapsulation through sound literally took the users into its midst, further reducing external factors and helping participants to focus their attention. The introduction of visual and phonetic accentuations eased concentration on both an auditive and a visual level. Last but not least, a variety of social cues (the presence of a vigilator, the presence of posters, etc) invited users to get actively involved. Heightened attention was expedited if personal interest was already prevalent. Last but not least, the absence of latency contributed enormously to user engagement.

Participant observation indicated a strong relationship between immersive sound experiences and presence. As a researcher, my role was to operate in the background, where I was able to document and protocol user's reaction without interfering. The second phase of the case study was concerned with explanatory research questions: How are immersive sound experiences affecting participants individually? How are key components of immersion related to the phenomenon? Which factors influence the effect of immersive sound in such a telepresence environment? And last but not least, how effective is immersive sound as a conveyor of telepresence experience. While the former questions were largely answered through participant observation and survey analysis, the latter was answered quantitatively through the evaluation of the Witmer & Singer questionnaire.

7.13. KIMA - one-shot case study as intervention

To ensure comparable, validated research results, the Witmer and Singer presence questionnaire (PQ) was conducted on a 7-point Likert scale. Some of the questions provided within the questionnaire had to be explained to the audience so to relate them directly to the technicalities of KIMA. The setup fulfilled all spatial requirements needed to qualify as a virtual environment and was strategically positioned at one of the key festival venues guaranteeing high visibility and high footfall. An independent invigilator administered the PQ survey, to avoid any experimenter bias. The questionnaire was only offered to users who spent time with the installation and familiarized themselves with its functionality. The results are published in the appendix of the paper and demonstrate an overall high presence score, pointing to a relevant relationship between immersive sound and presence experiences.

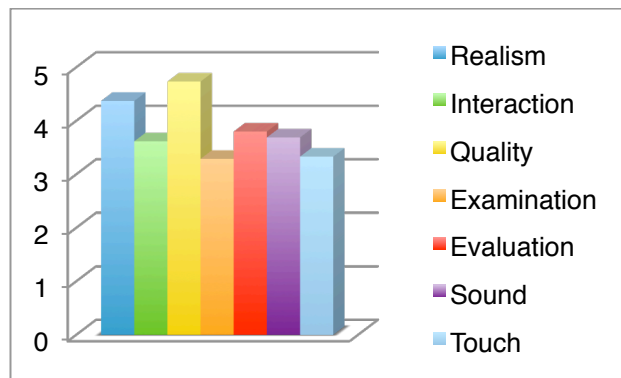
The Witmer & Singer Presence Questionnaire (PQ) has been criticized for failing to assure inter-comparability across different environments - specifically immersive environments compared to the real world (Slater, Usoh, et al. 2000). Freeman, Avons, Pearson & Ijsselstijn (1999) deplored the inherent instability in subjective presence

questionnaires. Efforts to introduce objective measures include heart rate, galvanic measures and skin conductivity (Insko 2001, Meehan 2003). An alternative instrument for objective measures consists in the analysis of brainwaves, an example presented in the second case study. Criticism in the use of the Witmer & Singer questionnaire concerns its normalising nature: Despite the fact that core components of presence are measured, the score itself is calculated as sum of *all* factors. Nevertheless, in a thorough review of existing presence research methods, Youngblut (2003) refers to Witmer & Singer's PQ as one of the foremost established instruments for measuring presence. The Witmer and Singer test has been used in numerous studies and can be seen as offering significant face as well as external validity as well as a high reliability with a Cronbach alpha of 0.88. As a subjective questionnaire, the PQ is exposed to subject bias, but not per se to experimenter bias (Insko 2003, Youngblut 2003, p. 15).

Presence measurements require academic criteria of good practice such as reliability, validity and sensitivity (Ijsselstein 2004, Hendrix & Barfield 1996, Youngblut 2003). The Witmer and Singer questionnaire's high inner consistency ($\alpha=.88$), is only surpassed by the Sas questionnaire (Sas and O'Hare 2001, Compare: Slater 2001). In Youngblut's thorough comparison of ten frequently used presence tests, the PQ was the only one demonstrating face validity, variation with related factors, stability for unrelated factors, consistency across studies and successful comparison with other tests (Youngblut 2003). Comparing between the most widely used presence questionnaires, significant correlations between the Witmer & Singer and Slater Usoh & Steed tests were demonstrated, indicating that these tests measure the same construct (Sas & O'Hare 2001, Youngblut & Perrin 2002, Youngblut & Huie 2003). The Witmer & Singer test originally offered 32 questions, which were subsequently reduced to 19 to enhance construct validity. This reduction in complexity tackled criticism on inconvenience in use and offered the possibility to cluster underlying factors into 7 subsets for further analysis. These clusters (Witmer & Singer 1994) are defined as realism ($f=7$), Interactivity ($f=4$), Quality of the Interface ($f=3$), Possibility to Examine ($f=3$), Self-Evaluation of Performance ($f=2$), Sound ($f=3$), Touch ($f=2$).

The analysis of these clusters assures a meaningful analysis of the effectiveness of the KIMA case study. Measuring the presence score not only across these categories, but also per cluster, helps to identify shortcomings and areas of successful impact within the KIMA setup. The mean of means per category shows high values for realism, in this case understood as fidelity of sound. This points to the conclusion that KIMA was extremely effective in this specific sub-category of presence. In addition, the evaluation of presence scores indicates high values for ease of interaction, and relatively high values for evaluation, quality of the setup, as well as self-examination (see chart below – Fig. 23)

Fig. 23: KIMA - Presence factor clusters



Witmer and Singer's presence questionnaires distinguish between 7 different dimensions: Realism, Interaction, Quality, Examination, Self-evaluation, Sound and Touch. Unsurprisingly, the KIMA intervention yielded relatively low values for touch compared to other dimensions, given that no haptic interface was available to users. Realism, understood as fidelity of the displayed image, refers to questions of consistency between sound and visual image. Realism also comprises questions on visual involvement and visual integrity, naturality of interaction as well as the portrayal of objects in space. KIMA fared very highly on this score item with a mean average of 5.8 out of 7 for realism on a Likert type scale of 1 to 7. Even higher was the score for self-evaluation, demonstrating that the initial concept, an interface for direct feedback on sound creation, was appreciated. High scores were also registered for Interaction (5.4 out of 7), Quality (5.4 out of 7), and of course Sound (5.6 out of 7). The grand mean of 5.49 with a standard deviation of 0.86 can be regarded as high. The Witmer & Singer questionnaire as well as the cluster the specific question is pertaining to can be found in the appendix.

The PQ sheds light on the presence quotient for KIMA, which ranked very high with a score of 5.49 out of 7. This is an above average score, also compared to the presence questionnaire of "Transmission", the case study discussed in the following chapter. Of specific interest are individual indices on sound identification, sound localisation as well as questions on involvement. These questions and their scores help the understanding of immersive sound in the creation of presence. With 0.67, the Cronbach alpha value of the KIMA case study was quite low, due to the rather small number of participants. However, the presence quotient is relatively high, as correlation of data with the UQO presence norm shows. The UQO population norm was calculated by the Laboratoire de Cyberpsychologie de l'UQO (UQO 2004). Comparing the KIMA presence score to the statistic norm provides an indicator for the effectiveness of the presence design compared to other virtual environments. Deviations from the statistic population norm indicate KIMA's statistic difference from other, successful virtual environments. This can be measured with a certain degree of significance and a certain confidence interval.

The UQO calculated the statistic norm for the presence questionnaire using a 1-7 Likert scale. With a sample of 101 participants, the UQO norm represents a benchmark, the outcome of a large-scale study to evaluate the Witmer & Singer presence questionnaire across a variety of virtual environments. The objective of the UQO consisted in the creation of a standard, a measureable norm to compare other virtual environments against. This standard provides an instrument for the evaluation of the KIMA setup. The UQO norm offers high construct validity with a Cronbach alpha of .84, only marginally lower than the original Witmer & Singer test. Given the specific nature of KIMA, the question whether KIMA qualifies and accounts for a virtual environment seems adequate. As a dual telepresence setup with a limited amount of photorealistic representation, KIMA is an unusual virtual environment. As KIMA uses exclusively immersive sound to create telepresence experiences, this norm presents a mechanism to evaluate the impact and effectiveness of immersive sound as a transmitter of telepresence experiences.

Norms calculated by the UQO: Mean Average Total		Standard Deviation
Total	104.39	18.99
Realism	29.45	12.04
Possibility to act	20.76	6.01
Quality of interface	15.37	5.15
Possibility to examine	15.38	4.90
Auto-evaluation of performance	11.00	2.87

Table 3: UQO norm for Presence questionnaire – Institut de Cyberpsychology - Université du Québec En Outaouais

	Total	Standard Deviation	Mean
Realism f=7	40.8	0.37	5.83
Interaction f=4	21.9	0.47	5.48
Quality f=3	16.2	0.22	5.4
Examination f=3	16.7	0.17	5.67
Self-Evaluation f=2	12	0.2	6
Sound f=3	16.8	0.22	5.6
Total f=19	107.9	0.86	5.49

Table 4: KIMA presence score as measured by the Witmer & Singer presence questionnaire

Compared to this (abstracted) norm, the KIMA PQ, based on presence for immersive sound, fares significantly higher than the UQO norm across all dimensions bar self-evaluation. The UQO norm does not apply to the categories “Touch” and “Sound”. Contrasting KIMA with the UQO norm, the relative success of KIMA’s effectiveness in establishing presence across a networked environment becomes apparent. The UQO norm also presents a viable instrument to falsify the null-hypothesis and to evaluate whether immersive sound contributes to presence experiences with a degree of statistic significance.

The research question for the KIMA case study was concerned with the effectiveness of immersive sound as influencing factor for presence experiences in a remote location. Technically, the research design intrinsically coupled telepresence to immersive sound. Immersive sound acted as the sole conveyor of remote communication. In contrast to the pilot's exploratory strategy, the second phase of the case study compared KIMA to the statistic population mean of other virtual environments. The UQO's presence questionnaire provides such a population mean validated across a multitude of virtual environments for francophone countries.

The relatively large sample and a Cronbach alpha of 0.84 assure reliability. The Z-test compares the UQO's validation norm (UQO 2004) with the KIMA setup. Hypothesizing that immersive sound can lead to heightened experience of presence in a remote location, the Z-test draws parallels between KIMA and the population standard deviation. The UQO validation established a norm of 104.39 as a population mean total for presence. With a significantly higher value than Witmer and Singer's mean average of 98.11, the UQO norm is ideally suited to test the setup for presence impact. Building the null hypothesis, mutually exclusive and exhaustive to the hypothesis, we can claim for N0 that immersive sound does not affect the experience of presence in a remote location. Following this null hypothesis, we assume no relationship between immersive sound and presence: Accordingly, we would expect the KIMA's PQ score results to be significantly below the UQO norm for virtual environments.

7.14 KIMA Case Study Results

The **hypothesis** assumes a measurable correlation between sound and presence, and consequently no significant difference between KIMA's presence quotidian and the presence quotidian of the population norm. The difference in PQ quotidian between presence questionnaires derived from standard VEs and presence questionnaires acquired using an immersive sound environment would need be significant for the null hypothesis to be true.

The KIMA setup reduces telepresence experiences to a function of immersive sound, controlling for other presence co-factors such as realism and interactivity. Under the null hypothesis, we would thus state that sound induced telepresence shows a significantly lower or higher PQ than the population mean standard as evaluated in the UQO presence norm validation (2004).

Furthermore, the null hypothesis would expect the value of the KIMA case study to be

unequal to the Witmer and Singer PQ mean average or indeed the standard population mean of the UQO validation norm. We can compare a sample value to the population norm using the Z-score test. The Z-Score compares standard errors to the statistic norm assuming no difference between sample mean and population mean. If the KIMA presence quotidian was significantly higher than the presence quotidian of the population norm, there's evidence of no statistically meaningful relationship between sound and presence.

Should the value of the PQ be significantly different from the statistical norm, the null hypothesis would be validated. Should the measured PQ value fall within the margins of statistical comparability, then we can assume statistical probability that immersive sound is directly related to the presence questionnaire. Or in other words, if there is a significant statistical difference, should the KIMA presence quotidian be significantly lower than the mean presence quotidian or the population mean of 104.39, then the null hypothesis would be true. We would need to assume that there is no strong correlation between immersive sound induced telepresence experience and the population norm. Given that the UQO norm has higher values than the PQ mean, we will test against this stricter / validated definition. The null hypothesis can be expressed mathematically:

$$H_0: \mu - \mu_0 \leq \text{Population mean } 104.39 \text{ or the PQ average } 98.11 \pm 15.78$$

$$H_0: \mu \leq 104.39 \parallel 98.11 \pm 15.78$$

Conversely, the **alternative hypothesis** assumes a significant dependency between immersive sound and presence. The Z-Test compares the results of a case study with the known population mean. As the null hypothesis and the alternative hypothesis are mutually exclusive and exhaustive, the alternative hypothesis can be assumed to be correct, if the null hypothesis is rejected and thus falsified. The Z-Value can be calculated with the Z-score test:

$N0 = PQ (\text{Observed}) - PQ (\text{Expected}) / \text{Standard Error}$. The z value investigates the probability of a difference between the standard error compared to the observed and expected values corrected by the statistical errors. In statistic practice the Z-test confidence interval is set with $P < 0.05$. In this one-shot case study, the probability is not split between higher and lower values of the statistic norm. Ergo, we need to compare the z value for $p=0.05$. The z-value corresponding to 0.05 equals -1.64. With a z-value outside this threshold, the hypothesis of no difference would need to be rejected. Appropriately, if the value falls above this values, the null hypothesis of similarity would need to be rejected with a significance level of 95%. The alternative hypothesis can only be confirmed, if the results of the presence questionnaire's z-score test fall outside this

range.

We can use the Normal Table to evaluate the percentile to this z score, leading to the probability value P. A z-score outside the range of statistic significance would mean the rejection of the null hypothesis and the likely probability of the alternative hypothesis.

$$H_a : \mu \geq \text{Population mean } 104.39 \text{ or the PQ mean average of } 98.11 \pm 15.78$$

$$H_a : \mu \geq 104.39 \parallel 98.11 \pm 15.78$$

$$z = \frac{\text{observed} - \text{expected}}{\text{S.E.}}$$

The formula for a **z test** is:

$$z = \frac{\bar{X} - \mu_0}{\sigma_{\bar{X}}}$$

The mathematical formula for the z-score is:

Our observed value is the Mean Total of the KIMA presence questionnaire, with the expected value being the UQO standard corrected by the standard error. The mean total of 107.9 has been calculated across all 19 questions, excluding any questions on sound and touch that have been disregarded by the UQO norm validation. The comparability of the two mean totals guarantees uniformity of the z-score's underlying base values. We can calculate the corresponding z-value by subtraction of the expected value of 104.39 from the grand mean total of the KIMA case study of 107.9. Correspondingly, the observed presence quotidian for KIMA created immersive sound is corrected by the expected value of the population norm and divided by the standard error as per the formula for the Z-test above. The standard error is derived from the standard deviation of the UQO norm validation set with 18.99 divided by the square root of the KIMA sample (n=11), which equals 3.32. Calculating the standard error, we divide the population error of 18.99 by the square root of the KIMA sample, i.e. 3.32, which equals 5.72. The Z-score for an observed value of 107.9 therefore amounts to

$$107.9 - 104.39 / 5.72 = 3.51 / 5.72 = 0.614$$

The related P value for a Z-score of 0.614 is $z \leq 0.615 = 0.729$ ergo the probability for immersive sound generated presence to be similar to the UQO presence norm equals $1 - 0.729 = 0.271$

With 0.614 the calculated Z-Score still falls within the range calculated for the significance level of $\alpha=0.05$. For a two-tailed test with a significance value of 0.95, z equals 1.975 and -1.975 respectively. The null hypothesis of a statistical indifference between

immersive sound generated presence experiences and the presence experience norm cannot be rejected. There is no statistic evidence that the KIMA presence quotidian is significantly different from the UQO evaluated PQ norm. With a P-value of the conditional probability of 0.271 our sample from the KIMA case study is statistically within the range of the population mean. Ergo the alternative hypothesis of statistical difference has to be rejected: The value falls inside the range set for statistic probability of similarity. As the P-value of 0.271 still falls outside the range of statistical significance, any proof of the likelihood of the alternative hypothesis would need to be the subject of further research. However, we can say with a significant probability of $\alpha=95\%$ that the presence questionnaire results of KIMA are statistically comparable to presence questionnaire results of the UQO norm. With a confidence interval of 2 and a population standard deviation of 18.99 we can then calculate the number of subjects needed to achieve the desired confidence for statistical significance of 0.05%.

$$n = \left(\frac{2z_{\alpha/2}\sigma}{w} \right)^2$$

$n = (2*1.975*18.99/2) * (2*1.975*18.99/2) =$ a total sample of 1405 random (sic) subjects would be required to achieve statistic significance to firm up the study's results. Although the results of the KIMA survey clearly indicate that immersive sound can generate experience of presence across a distance without the requirement for (kinetic) interaction and / or realism, the case study falls short of a number of key factors that would allow for more conclusive, reliable and objective results. Apart from a relatively small sample, a number of other factors tarnish the construct validity of this case study's results:

Not only has this study not been conducted using random samples, it also did not make use of a control group. Research results have been acquired in a quasi-experimental setup and its convenience sample has not been assembled using methods of randomization. However, results can still be seen as indicative for future research and explorations of the relationship between sound and vision. The second phase of the case study also firms up assumptions drawn from the KIMA pilot generated by focus group research, observation and the initial survey. Future research will need to concentrate on a strict experimental setup to assure construct and inner validity. Equally, intervening variables such as technical factors (inclusive cues, extensive cues, surrounding cues or vivid cues) or perceptual factors such as social cues, attention or temporal cues will need to be taken into account in quantitative research exploring this complex relationship. However, results point towards a strong relationship between sound and presence experiences contradicting prevailing research, opening the discussion for future research in the field.

7.15 Case Study - Discussion

Both phases in this case study point to the conclusion that presence and immersion are inherently linked and mutually influence each other. They also indicate that the prevalence of immersive, audio-visual cues positively influences presence experiences. These results are emphasised by the role attributed to sound in the research design of this setup. Sound is a constituent factor in the KIMA environment. Without sound, no presence experience is possible. Measuring the prevalence of presence through standardised research instruments, we thus validated a link between presence and immersive sound. The above studies signal that immersive sound and immersion positively enhance presence experiences. This assertion has been seconded by a large number of presence researchers (see: Biocca 1992, Skalski 2009, Schubert, Regenbrecht & Friedman 2001, et al.).

KIMA presented the users with technical and social immersion cues: On a technical level, we can apply Slater and Wilbur's classification system (Slater & Wilbur 1995) differentiating into inclusive, extensive, surrounding and vivid cues: KIMA's inclusive cue describe the physical setup, shielded from outside influences in both spaces - literally encapsulating the user within the environment. KIMA was extensive, in that microphone inputs added to the possibility in creating a real-time interface for the capture of atmospheric sounds. KIMA was surrounding, in providing users with a 5.1 surround speaker setup, and was vivid in offering real-time interactivity, emphasised by the colour spectrum and dynamic nature of the setup. On a social level, KIMA created interaction possibilities facilitated by an invigilator. Without sound input, the installation offered limited responsiveness, i.e. interaction and attention was required to bring the installation to life. And KIMA was temporary in offering limited latency and an ephemeral character in its display. The presence questionnaire points towards a strong relationship between immersive sound and presence experiences. Comparing KIMA's PQ results to the UQO Cyberpsychology Lab's (2004) validation standard (Cronbach Alpha of 0.84) we can evaluate the overall impact of immersive sound on presence.

With a Cronbach alpha of just 0.67 and a sample of only eleven subjects, the study can only be regarded as suggestive. Further research is required to firm up these results. The suitability of the Witmer & Singer presence questionnaire as research instrument has been questioned repeatedly, yet it remains one of the de-facto standards to measure presence, withstanding criticism of construct validity. The results of this case study only become meaningful when compared with qualitative data, as obtained through participant observation. The analysis of observational data indicates an above average sense of presence augmented through use of immersive sound.

The PQ quotidian of 131.9, with a mean of means of 5.49 on a 7-point Likert scale confirms strong impact of immersive sound on presence. Presence experience per person is even higher than the mean of means of the UQO norm (mean average of 5.6). Strong values per score category point to a strong role of immersive sound within the generation of presence: Specifically, immersive sound seems to contribute to perceptions of “realism” (mean per person of 5.8). As a contextual, inclusive factor, sound adds to real world experiences. In this setup, sound acted not as by-factor, but as fundamental facilitator: Perception of sound as instantaneous, actual, immediate and reactive establishes remote presence. High self-evaluation values (mean of 6.0) highlight the importance of sound as point of reference. As medium for real-time interaction (mean total of 21.9 and a mean of 5.8 out of 7) sound plays a crucial role in KIMA, linking two spaces in this mediated environment. Results only marginally divert from the UQO norm for presence. Falsification of the null hypothesis shows that immersive sound is not significantly different from the presence norm, and thus strongly related to presence.

7.16 Conclusion

With KIMA's research design, surround sound and its immersive qualities were exemplified and analysed as presence generating factors. The first phase of this two-tiered case study compared telematic surround sound with stereo sound on a holographic stage through a focus group, questionnaires and expert interviews. A significant majority perceived telematics sound and its real time representation as positively affecting their presence perception with varying impact of sound spatialization. Dominance of sound over vision, or vice versa vision over sound, could not be established during this intervention. Despite the absence of realism in this research setup, the vast majority of subjects reported an inherent relationship between surround sound and the feeling of presence. In the initial pilot, over 64% of the audience members named sound as key contributing factor to their feeling of immersion. Our research is consistent with Karsten Bormann (2005) and his findings on heightened presence perception with fully spatialized and attenuated sound. Bracken confirms the “power of sound” in the creation of presence (Bracken et al. 2010). The second phase, further strengthened the argument that immersive sound plays as co-factor of presence through inference of the hypothesis.

In a second phase, the case study investigated a number of audiovisual cues through inductive analysis (participant observation), further triangulating results with the Witmer & Singer questionnaire. An evaluation of the presence questionnaire results proved strong perception of presence and validated the hypothesis that immersive sound plays a key role as presence generating factor. Further research needs to be conducted into the complex relationship between spatial sound and its contribution to presence across different platforms.

If current research on the role of sound in presence is still inconclusive, the discussion of spatial sound has only just begun: Le Groux, Manzolli, and Verschure (2007) stressed significance of surround sound for immersion. Bracken et al. (2010) analysed spatial sound, comparing headphones and speakers. Bracken suggests a different experience depending on the type of media used: Headphones create a more immersive experience for smaller media such as headsets, whereas speakers lead to more immersion for larger screen displays. KIMA opens the discussion on importance of surround sound in the context of telepresence and VR. Direct comparison between surround and stereo sound suggests a substantial difference in the effect on presence. Whereas directional sound merely echoes an ongoing performance, spatial sound creates an immersive architecture that addresses spatial awareness – be it on a subliminal or a conscious level. Further research will need to look at adequacy of different sound formats for different media.

More than a research instrument, KIMA was developed as art installation, a real-time audience interface and a performance tool. This development culminated in a large-scale performance at Union Chapel London – supported by Arts Council England, Incloodu Deaf Arts Festival, and the Organ Project. KIMA's latest iteration is presented at the Roundhouse Camden. Showcasing and highlighting hidden properties of sound, the performance at Union Chapel made full use of immersive qualities of sound in the spectacular acoustic of the Union Chapel. A multitude of music instruments, percussion, viola, cello, voice and the Union Chapel's Henry Willis organ were visualized in real-time, creating a live interface for musicians, a singer and a dancer to perform with one another. KIMA was demonstrated twice at Incloodu Deaf Arts Festival as gateway to understanding music and sound for those of us, who cannot hear music but can feel and now even see it. KIMA was also showcased at Royal College of Music as a telepresence setup, allowing musicians to communicate across two rooms without physically seeing each other. The future of KIMA is not only in research, but as a visual music instrument, an interface for creativity, a performative medium.

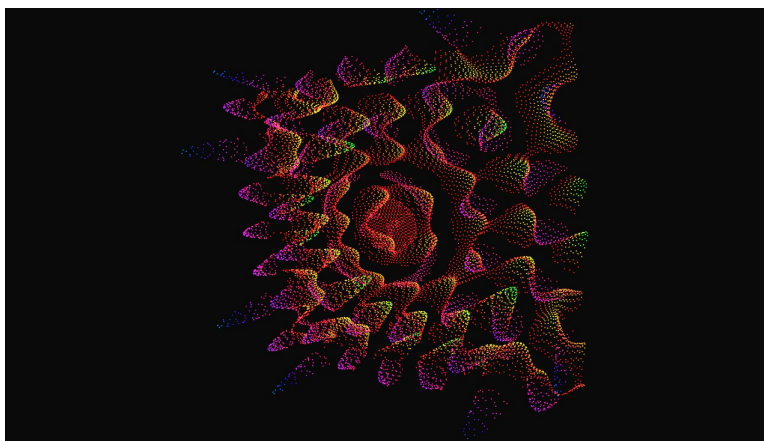


Fig 25: KIMA on Pepper's ghost holographic display at the Festival of Learning

After discussing immersion as key contributing factor of presence, the focus of the second case study lies on interactivity. Immersion and interactivity mutually influence each other, but remain distinctive phenomena. Immersion as more introspective experience focuses on individuals. Interactivity -an extroverted, exocentric phenomenon- concentrates on bilateral interaction.

The second case study -Transmission- researches interactivity as a co-factor of presence. Rather than through standardized tests, Transmission captures objective, quantitative data through its research design. Transmission contrasts quantitative data with questionnaires to yield valuable information on the role of interactivity in the generation of presence in the context of my creative practice. All three presented case studies focus on one specific aspect of the hypothesis. Accordingly, one single co-factor of presence is presented in the analytical model. Jointly, the discussion of these three co-factors contributes to the development of strategies for the optimisation of presence experiences on interfaces such as Pepper's ghost. All three case studies share roots in the context of media art. The second case study, Transmission, evaluates the role of interactivity in the creation of presence through an interactive environment for performance.

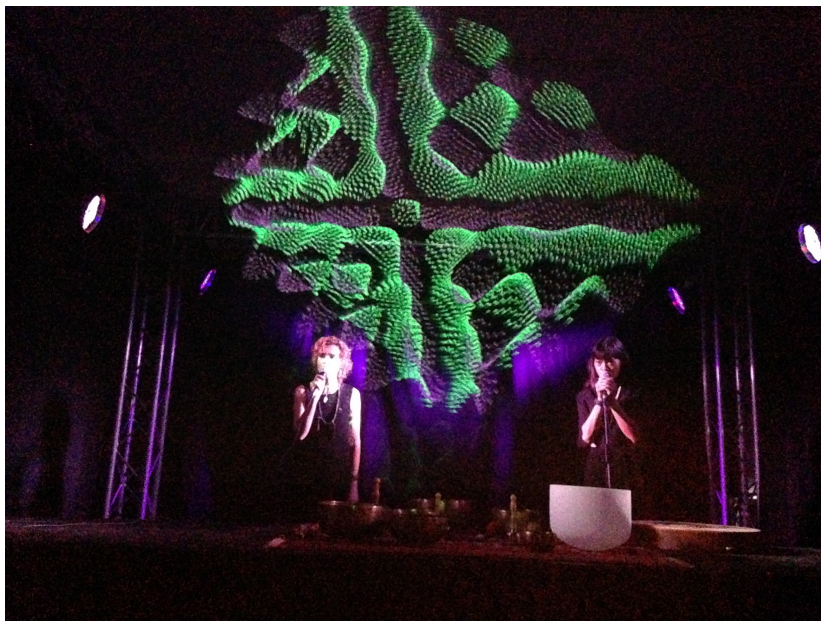


Fig. 26: KIMA at Kinetica 2014 – Evgenia Emets and Lani Rocillo

8. Transmission - Motion Capture Telepresence on Pepper's ghost – Case Study 2

Transmission - the second case study of this thesis, analyses the role interactivity plays in the creation of presence. Motion capture facilitates real time data streaming of kinetic motion across different spaces, a tool that can be used to create, modify and alternate visual representation of presence. Just as KIMA, Transmission acts as both a telepresence performance and a research project. As a real-time visualization tool, Transmission creates alternate representations of neural activity through sound and vision, investigating the effect of interaction on human consciousness. As a real-time representation of brainwave activity, it creates an immersive experience for two users: a visual manifestation of movement created by the human mind, manipulated by the influence of kinetic interaction of the audience. An electroencephalographic (EEG) headset interprets a user's neural activity as a real-time particle stream together with a dedicated sound environment at one end. A second user in a remote location modifies this stream in real time through body movement. Together they become a telematic musical interface, communicating through visual and sonic representation of their interactions. Like KIMA, Transmission was created in conjunction with Analema Group as art project conceptualised between the genres of generative and interactive art..

In digital art theory, the histories of generative art and interactive art are considered fundamentally interrelated, yet different, distinctive. A multitude of hybrid art forms challenge these definitions, questioning the conceptual nature of these two currents. Both genres share a longstanding tradition, a place in theoretical discourse and practice of digital arts. Their discussion has gained further momentum as both art forms received heightened attention in institutional discourse, curatorial display and theoretic reception. As an Art piece, Transmission is positioned between these two neighbouring fields in digital arts, presenting an example of a hybrid nature, a conceptual cross-over that challenges domineering conceptions of artistic genres.

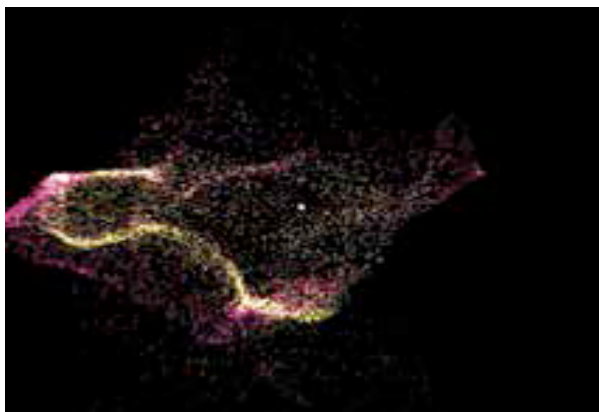


Fig 27: Transmission Pre-visualisation.

8.1 Transmission - Artistic Concept

Transmission is the second case study co-developed with the London-based collective Analema Group, in a series of art and research projects on telepresence. Using neurological data to engage audiences, Transmission offers users an audiovisual experience that reflects on affective bodily resonance via telepresence. Users explore their own thought processes and neural activity in real time, as well as the effect of kinetic interaction on their neurological processes. A user in a remote location influences these visual and sonic representations of brain-activity through motion-capture, an interaction that visibly manipulates the visual representation of brain activity. This interaction creates a feedback loop between inner, neurological dynamic and exogenous, kinetic movement. With Transmission, as audiovisual telepresence interface neurological processes and kinetic interaction merge into a new form of interactivity across two spaces. The technical aim of Transmission is to create an infrastructure to sonify and visualize brain activity during telepresence interactions.

Through motion capture techniques, the remote participant can directly modify the visual interpretation of his interactant's brain activity. Juxtaposing an inner, subjective and an external, kinetic activity, an electroencephalogram (EEG) provides users with feedback on the psychological effect of their interaction. Transmission presents a prototype to observe and measure the effect of interaction on brain-activity, and ultimately the effect of presence on neurological standards. The art piece is fuelled by participants' reactions, their respective introspective and extroverted communication. As research environment, Transmission provides information on effect of kinetic interaction in the context of my creative practice. Results are quantifiable and evaluated with the aid of standardised, qualitative tests.

This two-tiered case study investigates if and how interactivity and remote presence can be correlated in respect of my practice. The hypothesis proposes a direct effect of interaction on user engagement levels, and secondly a measurable effect of interaction on presence. The first phase consists in a technical pilot study, flanked by participant observation and interviews. In a second-phase, the hypothesis is scrutinised and investigated through an experiment research design, which is followed-up with statistic evaluation of presence questionnaires and participant observations.

As artwork, Transmission is rooted in the history of telepresence art, interactive art, and audiovisual art. Ever since Marcel Duchamp's Bicycle Wheel (Duchamp 2013), interactive art has been interested in user participation, chain reactions of cause and effect, and a conceptual as well as sometimes kinetic discourse between art piece, author, and spectator. Whether users are invited to write with their eyes as in Zach Lieberman's

Eyewriter (2010) or physically experience rain as in rAndom International's "Rain Room" (random International 2012), interactive arts tend to involve physical engagement as well as kinetic and bodily interactions. Transmission not only stands in this tradition of visible and reactive movement, but also shifts the focus onto invisible subtleties—in this case generated by the user's brainwaves.

With Transmission, Analema Group widens the reach of telepresence from mere physical involvement to psychological engagement, from the conscious to the subconscious. Kinetic movement invariably extends to our minds, our inner activities, a hitherto intangible dynamic of dislocated bodies. Contrary to traditional interactive arts, seen as going beyond psychological engagement (Compare: Paul 2003: p.67), Transmission places interactive art in the realm of the subjective, psychological sphere of the self. The juxtaposition of physical and psychological interaction and its neurological reaction builds the dialectic tension in Transmission. Ultimately, Transmission is not only interested in exploring a sense of presence, of being elsewhere, but also in a measurable effect of interaction on a remote user. Transmission is therefore not merely a media art piece, but a research environment, conceptualized with a specific research objective – namely to embody the role of interactivity in presence in the context of my creative practice.

This piece is introspective as much as extrovert, looking at the effect of presence on our own minds. Sound is an integral facilitator in this discourse of interaction between mind and body. Artistic engagement with neuroscience and music dates even further back, than the origins of telepresence art: avant-garde artists and pioneers such as Yoko Ono and John Lennon experimented with EEGs and music as early as the 1960s. Alvin Lucier premiered "Music for Solo Performer" at Brandeis University (Lucier 1965). By making use of the EEG-headset as a wearable device, Lucier interpreted brain waves to generate soundscapes. A few years later, Richard Teitelbaum's "Musica Elettronica Viva" used EEG signals to manipulate electronic synthesizers (Teitelbaum 1967). In 1971, David Rosenboom's "Ecology of the Skin" created an orchestra of EEG music by working with a multitude of live participants (Rosenboom 1974). As EEG headsets became more affordable, their use within the artistic and academic communities increased. Artists such as Eduardo Miranda, Andrew Brouse (Miranda & Brouse 2005), or Marina Abramovic (2011) developed sophisticated patches for EEG interaction. Contemporary neurofeedback-inspired art takes all new forms: Neam Cathode's Cyber Mondrian (2001) incorporated EEG headsets into an audiovisual environment. Artist Mariko Mori's Wave UFO allows for an immersive brain sonification experience in which users can climb inside a spaceship (Mori 2014). Lisa Park's "Eunoia" maps brain activity to vibrations of water (Park 2013).

On a purely academic level, Jeffrey Thompson studied the brain's reaction to specific frequencies. Sophisticated patches and interfaces for brain wave sonification were developed, for instance by Mick Grierson at Goldsmith University. At the same time, whole departments are dedicated to EEG and sound research: Neuromusic Lab at the University of Plymouth, Stanford's Neuromusic Laboratory at the CCRMA, University of British Columbia, Technische Universitaet Graz all concentrate on different aspects of research on the intersection between sound and neuroscience. "Transmission" is rooted in traditions of experimental sound, interactive arts, and telepresence art. The body's interactions, an extroverted bi-directionality between self and other, generate both a sonic and a visual imprint. Visual references for the design derive from ideas of connectedness, inspirations of flight data visualizations, and Leonardo Da Vinci's representations of the human body as network. Transmission thus facilitates an understanding of the human mind. Ethical questions are explored interactively. How invasive is it to measure emotions, linking these to visual representations, rendering the human's neurological transparent? The ultimate aim is to explore new visualization and representation techniques by introducing experts into the wider academic discourse. Transmission was exhibited at the Transmission Symposium on the 4th of February 2015 and subsequently installed as experimental research design at Bournemouth University's Executive Business Center to gain an understanding of the effect of kinetic motion on user perception of presence. As an art and performance project, Transmission remains a pilot project with the intention to develop the piece further, following its successful presentation at the Transmission Symposium and research experiment. The symposium itself led to the creation of a growing community of artists and researchers around the ideas of symbiosis between brainwave research and the arts.

The art piece Transmission was developed as pilot with Analema Group's core team consisting of Evgenia Emets, Alain Renaud, myself, the programmer Szymon Kaliski as well as an array of people interested in probing and developing Transmission for future use. Audience members can either be passive observers or active participants in this interactive exploration of brain-activity. Participants learn about their own reactions to interactions, ultimately reflecting on their reactions to interaction. The concept of contrasting introspective, self-oriented, almost meditative performative modes with exogenous, extrovert, kinetic movements, has met with a lot of interest from the academic community. This was reflected in demonstrations at EVA London, Siggraph as well as Kinetica Art Fair and the two-tiered Transmission symposium that provided the immediate context to the piece's development. The research itself helped to shed new light on the role that kinetic movement plays in the creation of remote presence experiences – specifically in the context of Pepper's ghost displays. The following chapters will discuss the project as a case study for presence research, investigating the effect of interactivity on presence in the context of my creative practice.

8.2. Case Study Protocol

A) Transmission - Case Study Overview

The Transmission case study focuses on interactivity as co-factor of presence. Oxford based presence researcher Floridi (2005 p.659) raised the fundamental question if interactivity qualifies as conditional requirement for presence experiences. Floridi reasoned that solipsistic telepresence experience would present an oxymoron in itself. Subjective methods in presence research have been criticised for their anthropocentric and Cartesian focus, their inability to assure academic objectivity. Presence research pretends to evaluate an objectifiable construct based on purely subjective assertions. The Transmission case study counteracts this criticism by presenting an objectifiable research method in evaluating the viability of the standard model in respect of my creative practice.

The software was developed to measure presence experiences objectively and quantitatively, analyzing the effect of bodily interaction on brainwaves as directly as possible. By obtaining data on kinetic bodily interaction, one can compare the effect of interaction on brainwaves before and after the intervention. Transmission's research design investigates statistic signal correlations between physical interaction and neurological activity. Research on limitations of brain-computer interfaces (BCIs) was conducted prior to artistic and technical development. The orchestration of two symposia on the role of BCI's in art and science led to an appropriate technical solution. Practice-based research furthered the pursuit of the research question.

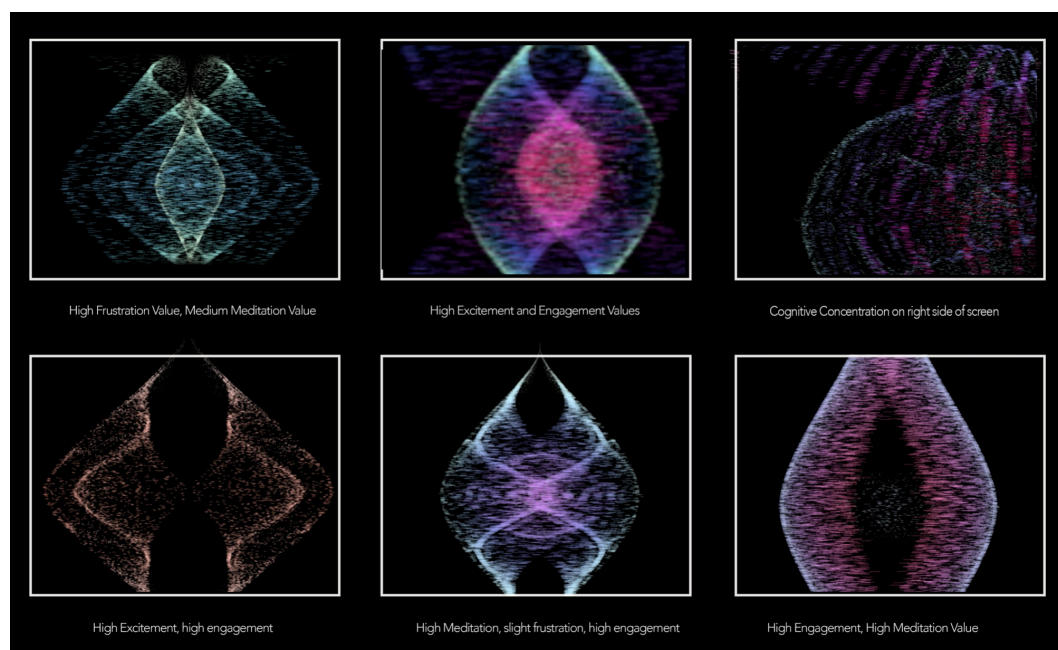


Fig 28: Transmission Visualisation

After in-depth consolidation with the academic community (artist Luciana Haill, QEEG practitioner Tony Seiffert, et al.), a strategy was identified to correlate neuroscientific data generated by the experiment with statistic evaluation of the Witmer & Singer presence questionnaire as validating variable. It is the commercial objective of the industrial sponsor to understand the effect of kinetic interactivity on the human brain, creating presence experiences with a specific focus on Pepper's ghost displays. The research objective is to investigate the effect of interactivity on telepresence experiences in respect of my own creative practice. The research method consisted in a triangulation of mixed methods: A quantitative experimental research design based on analysis of EEG data, was converged with statistical analysis of the Witmer & Singer presence questionnaire and qualitative research data generated through observation. Essentially an inter-subjective phenomenon, presence is mostly measured using non-objective, and non-falsifiable instruments for analysis (Floridi 2005, p. 659). The presented research design combats such criticism and reflects on subjective experiences of presence with objective data, focusing on the effect of kinetic interaction on users in the context of my practice.

The research design of Transmission combines a motion-capture interface for remote engagement with real-time visualisation of brainwaves for statistical analysis. Comparing brainwave data *a priori* and *a posteriori* of an intervention generates two distinctive sets for a paired T-test. Correllating this data to presence quotidian values illuminates the effect of interactivity on presence while guaranteeing repeatability of the experiment.

The research question examines whether increased kinetic interactivity leads to heightened presence experiences. The case study was conducted as a single-phase mixed-method experiment, on a random sample of fifteen people. A pilot study assured technical feasibility. The experimental research and the analysis of quantitative data was followed up with a presence questionnaire survey, and flanked by observation so to effectively triangulate methods.

The STM framework proposes interactivity as a fundamental co-factor of presence. Consequently, this case study hypothesizes that presence increases through interactivity with another person, and is ergo dependent on interactivity. The core of the case study consists in an experimental research design, visualising and sonifying brain activity manipulated directly through a remote user. Assuming that remote manipulation of brainwave visualization affects the values of this brainwave activity directly, the statistic change within this feedback loop was tested using value-comparison of the brain computer interface data. The quasi-experiment was conducted following strict academic standards, as well as approval by an ethics commission.

The case study's proposition investigated the validity of the STM framework in the context of my creative practice - in particular whether interactivity can be statistically related to presence experiences. The hypothesis assumes a statistic dependency between of presence (dependent variable) and interaction (independent variable). The null-hypothesis inferred from the hypotheses states that presence (dependent variable) is not affected by kinetic interactivity (independent variable). Under the null-hypothesis, interactivity does not affect brain activity itself (mediating variable) and does not lead to an increase in the perception of presence (dependent variable) as evaluated by the presence questionnaire. Confounding variables such as latency or social directionality of communication were taking into account.

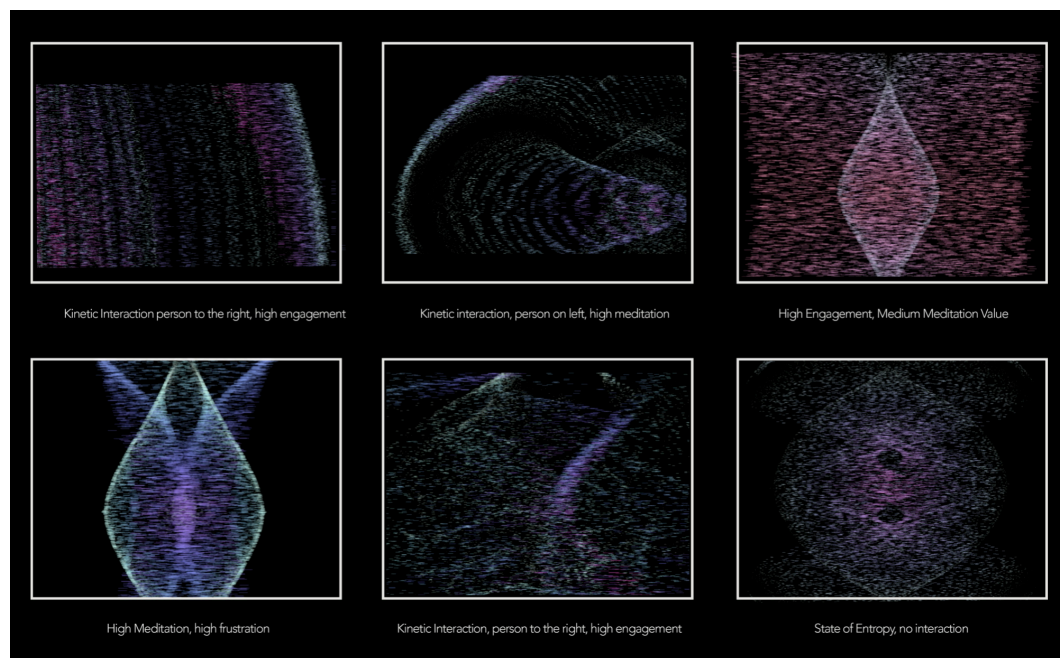


Fig 29: Transmission Visualisation - continued.

B) Data Collection Procedures

The research setup required the use of Brain Computer Interface (BCI) to gather, analyze and interpret brainwave data of participants. BCI's have experienced a substantial technical development over recent years, resulting in increase of use in academia, as well as for medical or therapeutic usage. The history of BCIs dates back to Richard Caton, who investigated brain activity of rabbits and monkeys, publishing the discovery of electric impulses in the human brain as early as 1875. BCIs are now in use for such wide range of applications such as ambulatory monitoring, control of prostheses, communication, neurofeedback and audiovisual art forms. BCI increasingly encompass an ever-growing number of artistic, educational, and consumer applications.

Definitions of BCIs vary from field to field: The 2010 Asilomar Survey reached out to 145 experts at the 4th international BCI Conference providing a degree of consensus in the scientific community on scope and reach of the terminology (Nijboer et al. 2013). The vast majority of interviewees agreed on a narrow definition for brain computer interface: BCI's detect and classify brain activity in real-time without using signals from nerves or muscles. Furthermore, BCI's must provide feedback to the user. However large the consensus within the academic community, inconsistencies in conception of the term persist.

Scherer defined a brain-computer-interface (BCI) as processing pipeline, originating from recordings of brain activity, producing data that assist human functioning (Scherer et al. 2013 In: Huster et al. 2014). BCI's are largely grouped into invasive and non-invasive instruments. This case study concentrated on non-invasive systems such as EEGs (Electroencephalograms). Invasive BCIs pose a higher risk to the patient or user and are considered more expensive, delicate and more difficult to administer. Non-invasive BCI's are perceived to be safer, but less accurate. Researchers moreover distinguish between three different types of non-invasive BCIs including EEGs that record electrical charges in the brain activity, magnetoencephalography (MEG) that evaluate magnetic fields emitted from electrical impulses of the brain and functional magnetic resonance imaging (fMRI) - measuring blood oxygenation during brain activity. Out of the three, EEGs have found the largest application in research, art and medicine, due to their ease of use, ease of transport, their limited costs and their effective use in clinical settings since the 1970s.

EEGs consist of electrode sensors usually measuring voltage fluctuations of neurons from 1-60 different locations of the human brain. Limitations of EEGs consist in their sensitivity to body movements. Electrical muscle discharges can be difficult to distinguish from electrical signals emitted by the brain. Standardized methods such as the 10 to 20 electrode placement system (EPS) or the geodesic sensor net (GSN) cannot ensure accurate repeatability of experiments as electrodes are difficult to place in absolutely exact same positions. Initial electrical signals in the region of only a few microvolts, are mostly emitted from the outer regions of the brain and further filtered by the membranes separating cortex from skull. These signals require amplification to become measurable. The frequency range in itself is limited and information transfer rates are still considered low. However, EEGs reflect post-synaptic activity, as well as intra-cortical processing well, and excel in temporary accuracy and low latency (Huster et al. 2014).

Complexity of BCI analysis increased in recent years, including reliability of EEGs. EEGs are considered an effective tool for neuro-feedback and its analysis (Chatelle et al. 2011). A wide range of diverse methods has been developed for the analysis of EEG and other BCI data - such as power spectrum, spectral centroid, Hjorth or event-related potential

(ERP). Each approach has its pros and cons - used to various different ends. Power spectrum analysis is using DFT or “Discrete Fourier Transformation” to analyse waveforms. Low frequency components, for instance, can be associated with drowsiness and high frequency components with a state of alertness.

Spectral centroid analysis measures the center of gravity over time, i.e. mid-frequency and amplitude distribution across a discrete period. Power spectrum analysis distinguishes between five different frequency bands *alpha*, *low beta*, *high beta*, *theta* and *delta* and their respective evolution over time. Hjorth-analysis measures activity, mobility and complexity of a brain wave signal. ERP, or event related potentials measure distributed processing of circuit elements as result of events - normally conducted as so called P300 trials. P300s spikes in brain activity follow a specific visual impulse. P300 trials require multiple tests to filter out noise and to guarantee measurability through repeatability of results. The reliability of BCIs as measuring instruments was proven repeatedly: As one of the most famous medical studies, the case of Ursula Broerman stands out. Mrs. Broerman developed Amyotrophic Lateral Sclerosis (ALS) in 2003, but managed to communicate to friends and family through BCIs despite developing a “complete locked in syndrome” (CLIS). Non-medical applications include the computer game “Mind the Sheep” developed by University of Twente. In the Arts, EEGs have been used since the mid-1960s.

In the now fifty-year long tradition of an emerging discipline, various different strategies for the interpretation of brain waves evolved. Methods and their effectivity improved significantly over the decades. Frequently, brainwave signals have been interpreted freely through artistic license. Not only is a solid medical understanding of the brain’s processing power rare within an artistic context, analytical instruments only recently became widely available to the artistic community - through lower price points and a diminished barrier to entry. Over the last decade artists have engaged increasingly with EEGs as non-invasive, and relatively effective BCIs in the creation of music and Art. Miranda and Brouse’s “Interharmonium” was developed in 2004: Algorithms based on power spectral analysis calculate and estimate subsonic frequencies in the predominant human brain wave band of 30Hz (Miranda & Brouse 2005). Mick Grierson (2008) describes the use of P300 tests, normally employed in medical setups, as a suitable tool to create music instruments. Mariko Mori created a brainwave interface of both visual and sonic dimensions based on power spectral analysis in her landmark installation “Wave UFO” (Mori 1999-2002).

In academia and the arts the choice of method for EEG interpretation not only depends on practicality of the setup, but also validity of results. There are several standardised methods for measuring ERPs including the P100, P200 and P300 test - referring to three

electrical responses that typically follow an audio-visual stimulus. These tests reflect post-synaptic electrical activity following an audio-visual incentive. Whereas the P300 test is deemed very reliable, a multitude of test setups is required to yield conclusive results. To ensure ease of use, and to avoid the repetitiveness of tests as required by the P300 test, Transmission interprets brainwaves through power spectrum analysis (frequency analysis) of EEG data.

From professional, clinical instruments to consumer headsets, various EEG providers offer units with diverging degrees of complexity: After careful consideration of available options, the choice for this case study fell onto Epoc's Emotiv EEG due to its affordability, relative complexity and its wide distribution within artistic and research communities. Functionality, validity and usefulness of this model as a research tool was tested and analysed in a number of studies (Badcock et al. 2013, Thie, Klistorner & Graham 2012, Debener et al. 2012). Emotiv's Epoc EEG relies on just 14 channels and 2 control channels rather than the 64 channels in use for medical applications, but more than consumer applications such as the Neurosky with 1 channel. Emotiv's Epoc is considered a high-resolution system and uses a sequential method at a rate of 2048Hz internal and a frequency response between 0.16 - 43 Hz.

Two sensors are acting as mastoid and reference signal to which electrical voltage of all other channels is correlated. The other mastoid (M2) is a feed-forward reference that reduces external electrical interference. Data is analysed locally by the Emotiv headset and interpreted as OSC messages assigned to affective and cognitive states. The Emotiv EEG uses gold plated contact sensors to capture EEG data. To measure Event Related Potentials ERPs -average electrical response of a certain amount of brain cells (neurons) to a specific audiovisual signal- it was necessary to capture the data at the exact same time as data on the event occurrence itself. Using a single script for brainwave data analysis and motion capture guaranteed such a synchronicity of events. Baseline values were recorded prior to the intervention over a period of 2 to 5 minutes. As the Emotiv EEG hasn't been developed to measure ERPs per se, signals were passed on via a Maxpatch (cycling74.org) to a processing script (processing.org) as open sound control (OSC) messages. These signals were captured using Java recording commands along with information on motion capture acting as stimulus for data modulation. The resulting script recorded stimulus modulation along with correlating brainwave values. Synchronicity of events assures that kinetic intervention could be correlated to baseline values of brainwave behaviour. Numerical peak values are recorded, normalised and subsequently compared against baseline values recorded before the intervention to ensure meaningfulness of results. The Transmission software visualises these results as sine wave interpretation of incoming OSC messages across two dimensions.

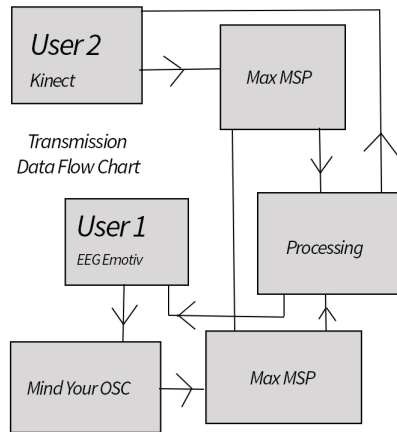


Fig. 30 Data Flow Chart

EEG Data on users' emotional state-of-being was interpreted by the Transmission software as complex particle visualization. A "Processing"-script mapped EEG input values to particle characteristics such as pace, particle size, colour, saturation and brightness. EEG values provided information on users' mediation, engagement, frustration and excitement levels – with various degrees of reliability. The values were provided by Epoc's Emotiv's analytical software "Mind your OSC". Particle direction vectors were mapped to cognitive input values, creating a sense of control impulse for the user. In essence, users were equipped with a simple toolset relating particles to their emotional states, coordinated by cognitive concentration.

The code associating brainwave attributes to the particle system was kept as simple as possible. This assured ease of interpretation and evaluation (see: Appendix). Engagement and excitement levels were linked to faster pace, warmer colours and higher saturation. High frustration values were attributed to green colours, meditative values to blue tones and slower movement. Sound events were related to ERPs (event related potentials) and value changes. This equipped users with a sliding scale of particle colouring with frustration on one side of the spectrum and high engagement on the other. Intuitivity of the visualization was relevant for this research. Despite overall responsiveness of the particle system, a degree of entropy ensued after several minutes, due to the large to assure ease of interpretation for users. Over the course of two to five minutes, engagement values – the most reliable EEG data- were recorded and their mean calculated as baseline value for the paired T-test.

C. Data Collection Questions

After an introduction to the dual nature of the piece as art and research project, users were prepared for the experiment itself. It was explained that EEG data would be used to visualise and sonify brainwaves, that data would be recorded for later analysis. The duration of the experiment was set with five minutes per participant. The research team explained that EEGs don't present any security hazard. No pictures or videos of participants were taken during the experiment.

Technical preparations included the attribution of an index to the user, assuring that the EEG was connected and registering on the MAX MSP interface through real-time value input. Users were furthermore briefed on the functionality of the interface: I explained attribution of colour values to emotive states and the possibility to "control" the particle stream through concentration. After two minutes of baseline recordings, the intervention took place.

Following the baseline recording, the intervention took place: Motion capture data modulated the same particle system further: As an assistant moved left to right in the second space, visualization of the brainwave data stream was manipulated. Motion capture visibly interfered with the particle system that had so far only symbolised the user's brainwave activity. Particles visibly reacted to the new input and followed motion capture in both pacing and directionality of movement. This visualization manipulated by motion-capture looked markedly different from the initial baseline-recording mode, so to be noticed immediately by the participant. The position of the user in the second space was recorded simultaneously to EEG engagement values in the primary space. Comparing control group phase values with post-intervention data, it was possible to analyse the effect of the intervention on the user's brain activity. The method followed a strict technical procedure, statistically evaluated in a paired T-test:

After about one or two minutes of kinetic interaction with the script, we explained users what had happened. After the experiment, a Wittmer & Singer presence questionnaire was handed out to measure the effect of interactivity on presence. On completion, participants were thanked for their involvement.

The purpose of this study is to test an elementary presence model, the standard telepresence model (STM) and to probe the relationship between interactivity and telepresence experiences in respect of my creative practice. A triangulation of methods was used to establish a link between interactivity and presence in an exploratory study. The research design made use of a quasi-experimental setup by comparing quantitative data generated by a standardized survey with EEG brainwave data. The dependent

variable of presence was measured through the Presence Questionnaire (PQ). The independent variable was defined as interactivity, intervened by latency, directionality of interaction and user control. The dependent variable (presence experience) was measured through the control variable brain activity as indicated by the EEG. The experiment design made use of a one-group pre-test post-test design. The sample was selected through an open call to academics and students at Bournemouth University. A paired T-test compared pre- and post- treatment group for significant data correlations. The power of the study (Cronbach Alpha) was relatively high with an alpha of 0.8.

The hypothesis tested the viability of the STM framework, assuming a significant effect of remote physical interaction on engagement levels (H1) and ultimately on presence (H2). To that end, the Witmer and Singer presence questionnaire was correlated with results from EEG measurements and their baseline values. Underlying factors were discussed analytically through the evaluation of participant observation. Questions raised in this experiment were mainly of exploratory nature, focusing on the prevalence of a dependency between interactivity and presence. Explanatory questions were outside of the statistical scope of the experiment setup, but were discussed through observation and the descriptive analysis of the presence questionnaire.

D. Guide for Case Study Report

The audience of the case study report consists of academics and researchers in the field of presence research, media artists, media scholars, and industry professionals seeking to augment presence experiences. The case study focuses on the role of interactivity in the generation of remote presence experiences in the context of Pepper's ghost displays and my creative practice. The interface was originally designed for display on a Pepper's ghost screen setup. Controlling for other presence co-factors such as realism or immersion, Transmission is exclusively concerned with interactivity as stimulator for presence experiences. Using objective, quantifiable data input, and triangulating this data with qualitative research, Transmission investigates interactivity as a key component of presence. Participants explore remote interactivity as interplay between inner perception and exogenous factors. Physical interaction results in a visual and sonic feedback loop. The case study report illuminates whether interaction can be validated as core component of presence as proposed by the STM framework. Documentation of the Transmission case study is presented as supplement to this thesis and as appendix.

8.3 Case Study Report - Transmission

With this case study research, the emphasis lies on the generation of a set of viable, reliable, and representative data that reflects both subjective, psychological as well as objective, quantifiable aspects of telepresence. Researchers highlighted the advantage of presence questionnaires over non-standardised surveys as easy to conduct, easy to answer and easy to evaluate (compare: Insko 2003, p. 3). Disadvantages include their subjective nature, amplified by time delays when being administered after an intervention. Construct validity can be tarnished by bias of participants. Last but not least, a lack of clear definitions and the impossibility to objectively measure outcomes further compromises their reliability. With the Transmission research design, objective and subjective research methods were triangulated so to converge research results and to alleviate frequent pitfalls of presence questionnaires. The Transmission case study focuses on interactivity as core component of telepresence as outlined in the STM framework. The case study's objective is to assure comprehensive research results, specifically in answering the following questions:

- *Firstly, is there a relationship between kinetic movement and engagement levels (H1)?*
- *Secondly, how relevant is kinetic interactivity for the conveyance of presence (H2)?*



Fig. 31 Transmission Pilot Test – Musion HQ Portland Place

This research design compares VR experiences pre- and post kinetic interaction to investigate its effect on presence. Whereas during the experiment, the audience was merely involved as subjects and interactants, a more performative mode is the final objective of the piece. As an art performance, the audience watches the interplay between meditative “constructor” – the brainwave activity- and an interacting performer or dancer, who modulates this representation in real-time on a Pepper’s ghost stage. The audience witnesses a new form of interaction between mind and body and is the main

focus of presence experiences. For the experiment itself, however, data capture rather than a live performance was the objective. Ergo, the audience's role was secondary and in the case of the experiment, omitted entirely so not to distract participants or to dilute construct validity of generated data sets.

8.4. Transmission - Technical Setup

Transmission uses two spaces: In space A, motion capture data is recorded and transmitted to Space B; Space B consists in a display environment, in which the user generates neuro-feedback for visual and sonic representation. A networked installation facilitates motion data transmission via a MAX MSP patch from space A. The processing patch (processing.org) represents this information visually in space A, where a MAX MSP script (Cycling74.org) analyses EEG and motion data, parsing relevant information onto the Processing patch for visual output. Processing excels at real-time visualization using Javascript and open sound control (OSC) as data protocol. Motion capture data is recorded via a Microsoft Kinect (developer.microsoft.com/en-us/windows/kinect), and sent as OSC messages across the network to the script, to manipulate the particle visualization generated by incoming EEG data. The resulting symbiotic audiovisual representation is displayed on a screen interface, such as a Pepper's ghost display. Sound, visual data, and motion data are streamed in real-time, allowing for their immediate alteration, thus creating a constant feedback loop between external motion and internal fluctuation of brainwaves.

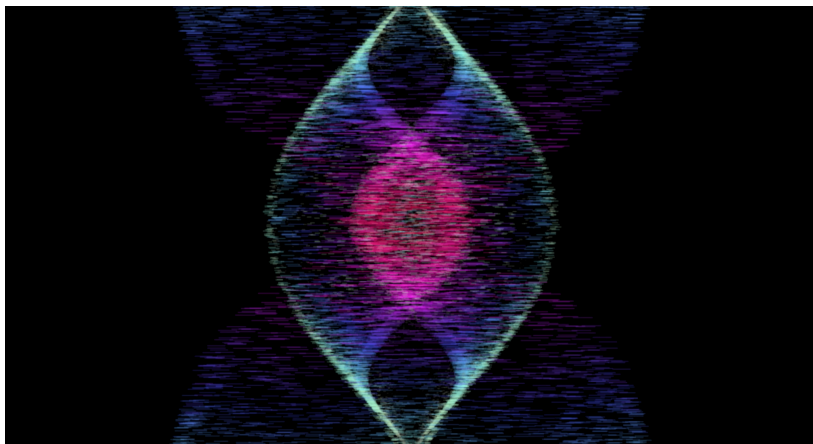


Fig 32 Transmission Brainwave Visualisation

In Transmission, “sonic events,” such as sound bursts and gentle vibrations, structure the experience and entail a clear indication of the type of brainwave activity, e.g. relaxation, meditation, engagement, etc. Sound was used with subtlety to accentuate readability of the experience. Brain wave data generated is sonified in real time using multichannel speaker diffusion with a sound design created by Dr. Alain Renaud. The resulting immersive character of the soundscape corresponds to the visual qualities of the

interactive display. Contrary to therapeutic context, where neurofeedback signals consist of beep tones, here participants listen to a continuous, pleasant and meditative soundscape.

After initial tests, a pilot was presented at the Transmission Symposium. The development of this prototype was the outcome of a collaboration with a visual programmer: Consulting, Szymon Kalinski, visual developer for the piece “The Sensorium” participated in this project. As a result, communication pipelines and protocol were simplified. This pilot and this collaboration helped to identify technical shortcomings, and to improve the reliability of the software. After careful evaluation of the pilot, the research experiment was planned and executed.

The experiment was installed across two adjacent spaces inside Bournemouth University’s Executive Business Center. The main space A was accessible to participants one at a time. A second space was only accessible to the assistant. Space A featured a computer running Alain Renaud’s sound patch, the processing patch, Emotiv’s Epoc EEG software “MindYourOSC” and a motion capture script (openkinect), integrated into the Processing patch. The computer was directly connected to the MOTU soundcard for surround sound output, as well as to the EEG and Kinect receiver. The Kinect receiver was connected via selfpowered USB extensions to the Kinect, which was setup in the adjacent room. Cables and wires were hidden under protection mats out of sight for the participant. A projector distributed the particle system interpretation of brainwave data onto a projection screen as well as onto reference monitors to the side. In Transmission, neurofeedback methods are re-contextualized artistically, giving participants tools for interpretation of their own brain activity. A biofeedback loop extrapolates abstracted mirror images of telepresence. Brainwave wave data is at once interpreted as visual representation and recorded throughout the experiment.

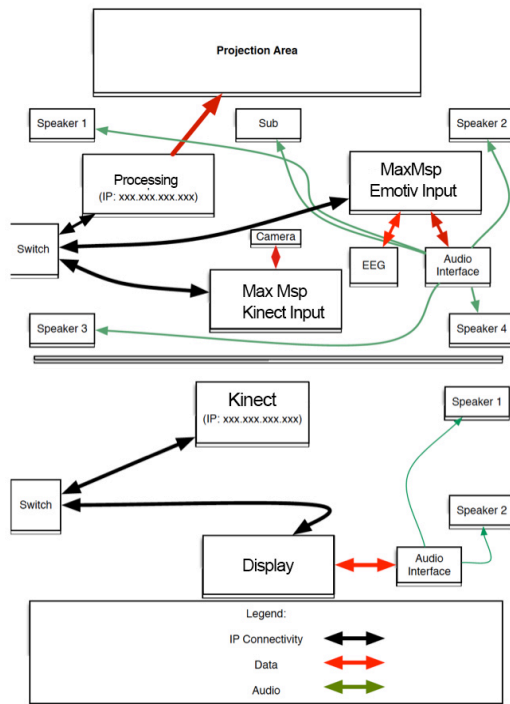


Fig. 33: Transmission Experiment Setup

The processing script made use of power spectrum analysis of brainwave activity. Affective states including “Meditation”, “Frustration”, “Boredom”, “Excitement” and “Engagement” reflect involvement of the user. Only engagement levels, earmarked as most reliable data sets (epoc.com), were used for the quantitative analysis. In addition, two cognitive values were included in the visual interpretation. Cognitive control requires a degree of training, usually for a minimum of five minutes. Inclusion of this functionality was based on the idea of control for users, providing users with an added incentive to actively engage.

A technical test run was completed prior to the installation. EEG transmission and Processing-data interpretation were optimized to avoid any technical errors. Preparations included projector testing, health and safety measures as well as extensive EEG maintenance to avoid artefacts due to corrosion. Nodes were cleaned and wetted to guarantee conductivity. Additional technical tests probed motiontracking latency. The questionnaire was adapted marginally to reflect the specific nature of the installation (see Appendix). Last but not least, the write-out module of the processing script was tested to assure both baseline recording and EEG data recording were reliable. An assistant was available to help with participant briefing to avoid any researcher bias. A strict procedure was adhered to for every participant. This standard process assured repeatability for all fifteen subjects. Nevertheless, only twelve out of the fifteen data sets were usable. Two of the data sets had to be omitted due to write-errors of the script. One data set indicated a

fault in the placement of the EEG. The experiment was not free of technical and conceptual challenges due to a complex technical pipeline:

First and foremost, the EEG output was analysed by the EEG software – Epoc’s “MindYourOSC”. As laid out in case study report, the software is validated for academic contexts. Yet meaningfulness of some of the data, specifically neurological relevance of affective states remained questionable. Due to missing transparency of internal functionality of the software, I decided to use only the most reliable set of data (engagement levels), and to concentrate solely on a before and after analysis rather than intra-comparison (covariance) between different data values. The use of only a single EEG data set also assured limited latency of the script. Engagement levels of users were measured as discrete values ranging between 0 and 100. Another challenge consisted in synchronicity between recording of motion capture data and EEG data. Java commands translated these values into a text file of two columns. This assured that EEG data and motion capture data could be analysed side by side for any correlation between mean average of generated data before and after the intervention.

8.5. Subjects

The experiment was conducted in mid-March 2015 at Bournemouth University’s Executive Business Center. The CDE – Center for Digital Entertainment under guidance of Daniel Cox issued an open call to researchers and students at Bournemouth’s Media School. A total of 15 participants, seven male and eight female, completed the experiment. Six of the participants were between 18 and 25, 3 between 25 and 30, 1 between 30 and 35, 2 between 35 and 40 and 3 above 40. The mean average was 29.8 years of age. The sample consisted in a convenience sample, derived from the university’s pool of academics with a pronounced interest in the field. Due to inconclusive EEG data, three data sets had to be dismissed on grounds of technical errors and were exempt from further analysis. This data was not included in the paired T-test data comparison, but is included in the analysis of the presence questionnaire as well as in the report on participant’s observation. All participants followed the same procedure in accordance with the case study protocol.

8.6. Transmission - Participant observation

The pilot to the (quasi-) experiment took place beginning of February 2015 at the Transmission Symposium. The research design was tested by the research team and presented to the public. Key technical and conceptual shortcomings of the setup were identified during the pilot, and subsequently tackled. The art collective Analema Group

studied and tested interaction possibilities and evaluated its use for research purposes. Participant observation involves the researcher and his team, demanding an active process of decision making on their part. Researchers establish a priori as well as a posteriori, which observations are relevant for the academic discussion. This form of judgmental sampling is regarded as a form of non-probability sampling (See: Jorgensen 1989), and is required to be rationally defensible. Judgmental sampling presents the logic for selecting particular angles of the study. Such a theory tends to be structured into parts, elements or units of analysis. These discreet units of analysis were directly derived from the overarching theoretical construct – the STM framework. Conceptually, this framework differentiates between three variables of interactivity derived by Liu and Shrum: dimensionality of communication, temporal cues and active control. These three components of interactivity present our units of analysis for participant observation.

Dimensionality of communication, concerns the degree of interactivity in both directions: How is User 1, wearing an EEG, able to interact with User 2, communicating through kinetic movement. What feedback mechanisms are at their respective disposal and how can they be improved. The second variable concerns time: What is the extent of delay and are there repercussions on user experience? The third dimension concerns user input modalities: The idiom “active control” describes means of interaction for an individual within a specific setup. During the pilot, all three elements were analyzed separately, so to challenge shortcomings of the installation. A number of steps rectified initial issues of the research environment monitored during the pilot:

- a) **Dimensionality of Communication:** The pilot indicated that flow of communication for User 1, wearing the EEG, was perceived as limiting. Being reduced to merely a passive medium, the user felt deprived of ways to interact with the visual representation: Although data visualization was a direct result of the EEG data stream and only modulated through motion control, affective states are difficult to control directly: Emotions such as boredom, or excitement are not easily invoked other than through meditation. As a result, the decision was made to add cognitive data input, so to give users more control. Through the ability to manipulate particle's directionality by means of concentration, dimensionality of communication was sustainably improved.

- b) **Temporal Cues:** During the pilot, the installation was deemed too slow, and not reactive enough to indicate immediate effects. The focus group pointed to a knock-on effect of latency on overall perception of the piece. Not only was sound regarded as disjointed from animation, the interaction itself was considered too slow and not intuitive enough. To combat this perception, the

script was improved, redundancies eliminated, and the overall reaction time increased. Specifically, connection between sound and visuals was optimised.

- c) **Active Control:** The complexity of the installation was enhanced to facilitate plurality of affective state representation. Cognitive parameters were represented visually. The sound design was adapted to reflect the characteristics of brainwaves better. Motion capture input was reduced to one dimension, the X-axis or horizontal axis to avoid entropy where possible.

Prior to the experiment, findings from the pilot were implemented. Analysis of quantitative data indicated limited construct validity through a relatively small sample, despite a cronbach alpha of 0.8 percent. Furthermore, the design's construct validity had to be scrutinized as EEG data relied on commercial soft- and hardware with its own set of limitations. Compensating for quantitative and technical shortcomings, participant observation provided a useful complementary instrument for convergence of research results.

The procedure for the experiment followed the case study protocol: An assistant briefed participants on potential risks, scope and background of the research agenda, duration and remit of the study. All attendants had to sign a release form and were informed of the non-intrusive nature of the EEG.

Ahead of the experiment, an alphanumerical value was assigned to the participant and indexed for anonymous identification of EEG data. The EEG was wettened and switched on, the sound patch started, and last but not least the visual patch was initialized via the Processing script. The script itself was automatically launched as soon as EEG input was registered. This guaranteed a seamless flow of OSC messages from EEG to Processing patch and validated the data flow prior to recording. While the user started to experience his or her brainwave interpretation audiovisually, users were briefed on particle representation. Together with the second phase (*Fig. 34*), this initial minute formed the baseline recording against which post-intervention data was compared.

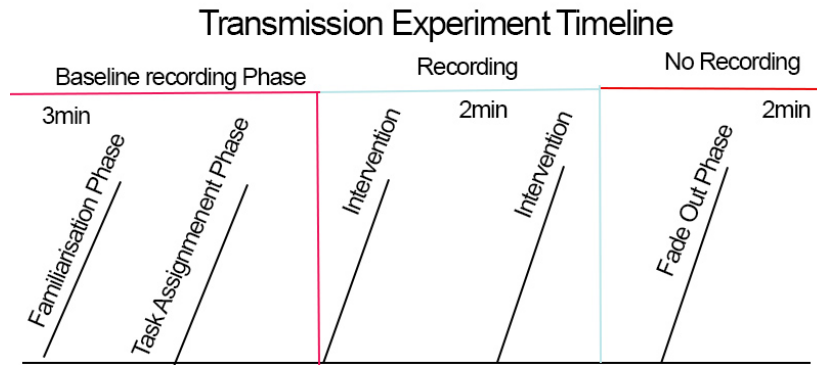


Fig.34 Transmission Experiment Timeline

The second phase consisted in task assignment: I explained the possibility to navigate along the horizontal axis of the particle stream exclusively through concentration: Focusing attention either on the left or the right side of the screen, particles moved in the respective direction. Users were invited to manipulate particle position in such manner for another two minutes. During these two minutes (Phase 2), the assistant - standing behind the back of the participant- would silently leave the room. Recording time of two to three minutes was too limited for sufficient training in cognitive software control. In quantitative EEG measurements a minimum of five to fifteen minutes is required for training. This experiment was never designed to measure control of brainwaves, only the effect of an intervention, i.e. remote presence experience through interaction. The baseline value recording was reduced to three minutes to guarantee a maximum number of participants in a short timeframe.

After the baseline recording phase, the intervention took place: Following a remote signal, the assistant, secretly having left to the adjacent room, started to move in front of the motion capture device (Microsoft Kinect). As soon as the motion capture camera picked up the signal, brainwave visualization markedly changed its characteristics: Particles became denser, more pronounced and now followed the movement of the assistant as opposed to the participant's cognitive EEG input. The duration of the intervention lasted an average of two minutes, long enough for the user to realize that something interfered with their data input. After the intervention, the system was reset to single user mode. To avoid any feeling of frustration, users were given a complete explanation of the functionality. Additionally, participants were invited to familiarize themselves with the program for another minute. Participant observation pointed to a large variation in reactions. Responses to the motioncapture-triggered intervention differed from frustration to surprise, from irritation to excitement. The breadth of reactions is presented on a pars pro toto basis using a method of analytic induction to interpret observed data.

Users' reaction varied enormously depending on their degree of comfort and familiarity with EEG headset. Rather than a study in presence, the piece was predominantly perceived a personal investigation in possibilities and limitations of brainwave measuring technology. Despite responsiveness of the system, users were critical of technical possibilities of brainwave interpretation. The vast majority of users reacted with both interest and disbelief about abilities of brain-computer interfaces, specifically the potential to measure engagement or to control the particle stream. The diversity of reactions ranged from mere interest to enthusiastic engagement, from amusement to frustration, from anger to hysteria.

The first three participants demonstrated intuitive and seamless interaction with the virtual environment and ultimately their own brainwave representation. All three displayed surprise, interest and excitement interacting with the VE and their invisible interactant. One of the participants, who was just on her way to a yoga class, had a lot of experience in meditation. She found it very easy to control the particle stream with hardly any introductory training. Other users found it harder to "interpret the colours assigned to the particle stream or indeed to control them. Whereas some users instantly connected with the installation, were able to maneuver particles from left to right and back through cognitive concentration, others perceived the exercise as more challenging. Two users felt completely incapable of controlling direction of the particle stream, or to influence colour, density or size. Even after verbal explanation of the functionality of the setup, they struggled to recognise the relationship between visual representation and their own affective states. One user was only capable of navigating particles into only one specific direction. When I was checking the EEG for faults, she explained that she was diagnosed with a specific neurological condition as teenager and was expecting these results.

Regardless of users' ability to control the particle simulation, the intervention was triggered about 2 minutes into the individual user's experience. The motion-capture intervention resulted in a visible shift in particle directionality. This was greeted with different reactions ranging from bewilderment, to amusement, from anger to false sensations of success. Responses were diverse, subjective and unpredictable. Yet all users reacted instinctively to the change of behavior in the simulation. The intervention never remained unnoticed. Whereas some users thought to have gained control of the system, others recognized an element of play. Almost every participant recognised the intervention as disruptive, exogenous event. The particle stream turned visibly denser as the contours of a person appeared to "drive" the particles' directionality. The signal, hitherto understood as introspective and self-referential, as a mirror to the soul, became a tool for interaction. As if an invisible hand unpredictably intervened, the particle simulation followed the stylized directionality of another person. No later than a minute into the intervention, users were informed about the nature of the modification, that a user in a

remote location was causing the signal variation through movement. Users were notified that an intervention had taken place so that presence could be actively monitored using the EEG. The EEG thus measured not merely the reaction to a changed signal input, but moreover the reaction to remote presence itself.

After the intervention was completed, users enjoyed another one to two minutes interacting with the piece. Following the experiment, the presence questionnaire was administered to identify shortcomings of the interface, its effect on the audience and the degree of presence created through the intervention. The Transmission experiment analysed interactivity as a potential co-factor of presence according to the STM-framework in respect of my creative practice. The STM framework discusses interactivity across three pivotal components of interactivity – active control, temporal cues and dimensionality of direction. The analysis of participant observation follows this classification system of the STM model:

Dimensionality of Direction: In order to augment dimensionality of direction, cognitive functions were implemented. This allowed users to alter the direction of particles by focusing their thoughts. In essence users in both spaces were confronted with the same visual interface. Ergo both were equally able to manipulate the particle stream, one through thought and one through movement. Not all users demonstrated an ability to make use of this cognitive functionality. Cognitive manipulation requires a minimum of five to ten minutes of intensive training. The timeframe did not allow for such intensive training. Accordingly, users taking part in the experiment indicated liminal proficiency in their ability to use cognitive possibilities fully.

Temporal Cues/Synchronicity: Despite low latency, the evaluation of the Witmer & Singer presence questionnaire indicates just average satisfaction rates for delay (3.6 on a 7-point Likert-scale). This was the result of a very complex data pipeline, from EEG, to OSC Engine, from Max to Processing to projector. Users were expecting immediate results, on perceived change of emotion or cognitive input through a spatial focus.

Active Control: The Transmission script translates affective states into colour codes, representative of engagement levels. User's excitement is mirrored not only in colour hue and brightness of particles, but through pace, size and intensity (saturation). Although Transmission was designed as intuitive interface, the novelty of such a display required an explanation to become operational, usable and understandable. After an initial phase of trial and error, most users managed to actively control the stream, whereas others felt disengaged and

confused. As the aim of the experimental setup was not to ascertain users' ability to control, but only to measure the effect of interaction on brainwave activity, such ambiguity of reactions was secondary to the research goal itself.

Interaction: The moment the physical intervention took place, i.e. EEG representation was manipulated through motion capture, a noticeable, visual change occurred. The event was directly followed by heightened user activity. This behaviour was not only observed, but measurable through analysis of EEG data: A characteristic of observed reactions was their ambivalence. Virtually none of the users was left disengaged by the change caused by kinetic interaction. The intervention resulted in a (measurable) shift of behavior, a sense of recognition and an element of play. Some users tried to rationalise the intervention, others attempted to influence the particle stream to counteract the manipulation. The idea of joint control, of changing dominance, of interplay resulted in measurably increased attention.

To sum up, participant observation shows a high level of engagement, which further increased following remote, physical interaction. Users responded to the intervention with intensified participation. The ability to actively control particle shape, form and direction provided users with the ability to "master" a tool. No longer regarding the interface as a mirror to one's individual feelings, but as exercise and challenge, communication turned bilateral and interactive. Users behaviour observably changed as a result. Time, as a key factor not only for presence and interactivity, but also of causality (Cavazza 2007) played a significant part in perception of presence. All of these observations were seconded by the statistical analysis of recorded EEG values and presence questionnaire.

8.7 Case Study Evaluation

The evaluation of the Witmer & Singer test shows a comparatively low impact level for presence. The experiment demonstrated a very high cronbach alpha of 0.8. The value points towards high inner validity of the test, and above average values for quality of the feedback system: Delay received average scores - a mean of 3.6 on a 7-point Likert scale. This value is consistent with participant observation and verbal feedback by users. The mean average for delay is significantly lower than KIMAs perceived latency values. Control mechanism and visual display were perceived as intuitive to use. The mean average for quality as property of presence was higher than average with 4.7 points on a 7-point Likert scale. The installation also demonstrated above average values for realism and self-evaluation, and average values for interaction and examination.

Low marks were attributed to the quality of sound and the ability to move around the installation. Arguably, both factors had been neglected in the conception of the setup. Movement was not a key feature for participants wearing the EEG headset: 33.3% of audience members reported not being able to examine objects well from up close. Moreover, a third of all participants lamented the ability to move around inside the environment. Even though participants were not restricted per se, audiences were not engaged on a sensomotoric level. Sound was the third presence construct receiving sub-average rating. Notably, the ability to identify sounds was criticised by a large number of participants: 53.4% reported not being able to identify sounds at all (1 on a 7-point Likert scale) or not very well (2 point on a 7-point Likert scale). This shows a lot of room for improvement for Transmission as a multi-dimensional telepresence interface.

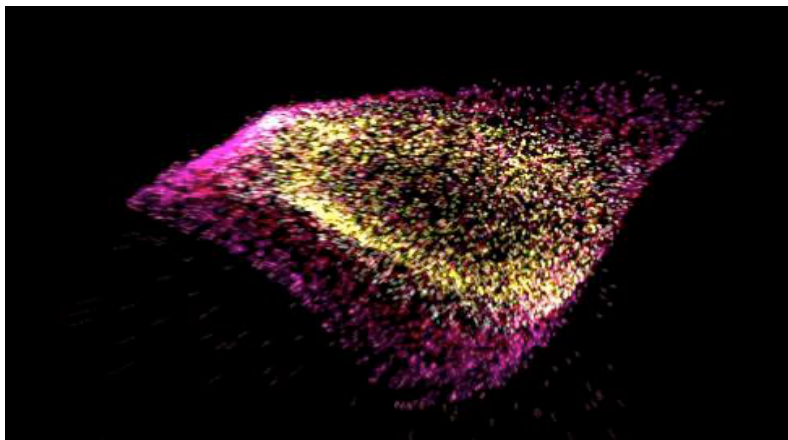


Fig 35: Transmission Previsualisation

User experience indicates high user-satisfaction of realism (mean of 4.3 out of 7 on the 7-point Likert scale). Here, realism is understood as fidelity of audiovisual representation, mirroring participants' affective sensibility. High values for realism can be attributed to high visual engagement, as indicated by 40% of participants. Transmission succeeded in its primary objective, to represent brain activity meaningfully. Additionally, 40% of participants reported a high level of immersion, measured as completeness of engaged senses.

To summarise, Transmission received positive feedback for visual impact, but low ratings for sound. Key factors of presence can be improved such as intuitivity of the interface or the ability to move around. A third of all respondents described their ability to control events as average. However, the majority of participants regarded the Transmission visualization as very compelling. 60% of all respondents rated the visualization with above average values and attested a compelling sense of objects in space. However, a higher degree of control could lead to improved ability to interact. The Witmer & Singer presence questionnaire also shows relatively low levels for confusion and received very high ratings for quality. The mechanism was considered natural to operate (mean of 4 out

of 7-point Likert-scale). Despite a low overall presence coefficient, which can be attributed to the missing component of touch, the presence questionnaire shows high approval ratings for quality of experience and realism.

The PQ test provides an indication of overall impact, but also reveals shortcomings of quantitative research. The Witmer & Singer presence test alone cannot capture the variety of audience responses. Although standard deviation of presence constructors never surpassed 1.1 on a 7-point Likert scale and standard deviation per person was reasonably low (17.64), user reaction differed largely from person to person. This shows the limits of quantitative research in capturing a highly complex construct such as presence. To validate the impact of presence, we need to look at an adapted presence quotidian – corrected by the categories sound and touch, both disregarded by the UQO norm. The presence quotidian for Transmission over these 19 questions is 76.73.

Paired T-Test

The paired T-test helps to draw conclusions about the impact of an intervention. Paired T-Tests compare a unique sample of n-participants before and after an intervention. In this case, we compare EEG data on user engagement between one and the same sample. Using data recorded before the intervention as baseline recording substitutes the need for a control group. Such a statistic evaluation is standard practice in clinical pre- and post trials. The null-hypothesis in a paired T-test assumes no significant difference between the two test groups. To compare the scores, one calculates the mean difference for both test groups.

The hypothesis is based on the assumption of a direct relation between interactivity and presence. This quasi-experimental setup concentrated exclusively on the discussion of interactivity, controlling for the other two co-factors of presence, realism and immersion. The effect of interactivity on presence was measured indirectly through brainwave data. Linking EEG data to the dependent variable user engagement (H1), and in a second step the presence questionnaire (H2), we gain further insight into the suitability of the test. This quantitative, exploratory study investigates the effect of interaction (independent variable) to presence quotidian (dependent variable). The hypothesis assumes a statistically measurable effect of interaction on brainwave experiences (H1) and the ability to measure presence as a result of kinetic interaction (H2).

Conversely, the null-hypothesis postulates no statistical difference between baseline recording (control) and post-intervention data and thus stipulates no significant effect of kinetic interaction on brainwave activity.

$$H_0: \mu d=0$$

Secondly, the null hypothesis also assumes no statistical relationship between interactivity and presence.

$$H_0: \mu_0 < \text{Population mean } 104.39$$

Vice versa, the alternative hypothesis assumes a high statistical probability for a relationship between interaction and presence. The null hypothesis states that kinetic interaction will not result in a higher level of engagement levels.

$$H_1: d \neq 0$$

In case of the falsification of the null-hypothesis, we therefore need to conclude with a degree of statistical probability that higher engagement levels derive from kinetic interaction. In order to probe the null hypothesis, we need to set a critical significance level. In academic practice such confidence levels are generally set at 95% or $\alpha=0.05$. The alternative hypothesis assumes a positive relationship between kinetic interaction and heightened engagement levels if the paired t-test yields results with a higher confidence level than 95%.

Following this initial test, we can then compare the results with the presence quotidian. The second hypothesis assumes that higher kinetic intervention leads to perception higher presence. Comparing the presence quotidian of Transmission to the UQO presence norm, we can calculate if Transmission evokes a measurable degree of presence. Provided H1 is correct, a higher degree of engagement through kinetic interaction would entail a higher degree of presence (H2).

Table 5: UQO Witmer & Singer Presence Norm and Transmission Mean Average Results

Norms calculated by the UQO: Mean Average Total		Standard Deviation
Total	104.39	18.99
Realism	29.45	12.04
Possibility to act	20.76	6.01
Quality of interface	15.37	5.15
Possibility to examine	15.38	4.90
Auto-evaluation of performance	11.00	2.87

	Mean	STDV	Total
Realism 7	4.371428571	0.691772183	30.6
Interaction 4	3.616666667	0.862006703	14.5
Quality 3	4.7	0.881637086	9.4
Examination 3	3.288888889	1.123926099	9.9
Evaluation 2	3.8	0.4	7.6
Sound	3.688888889	0.930684071	11.1
Total (w/o sound)	3.72	18.62853248	76.73

To establish whether kinetic intervention engenders a higher degree of engagement, the paired T-test presents the most appropriate statistic tool to compare before and after

values in quantitative research. The paired T test or Student T-test is considered a sensitive evaluation method for comparing matched-pair, interval data by the same user. William Sealey Gossley introduced the Student T-test in 1908. The paired t-test assumes that two pairs of data are statistically different and that all deviations are following a normal distribution. Extreme outliers are taken out of the equation. Paired Student t-tests are used in medical trials to compare different values across the same sample and follow a number of steps: The null hypothesis assumes that t samples are equal. By means of falsification the null-hypothesis measures if there is significant difference before and after an invention. To arrive at this result, we first calculate the difference for each pair (before and after per user). Secondly, we compute the mean value of differences as well as the standard deviation of differences. Most importantly, we then calculate the T-statistic, which under the null-hypothesis follows a t-distribution with n-1 degrees of freedom. Comparing the T-value to the t-distribution via a look-up table provides the probability value p indicating the statistic probability of a measurable difference. The Confidence Interval (CI) is set with 95% in academic practice. Following the above steps, we calculate the **mean value of the differences** for all users as well as the standard deviation of differences. The test parameter is $t = (\text{Mean} / \text{SD}) * \text{sqrt}(N)$.

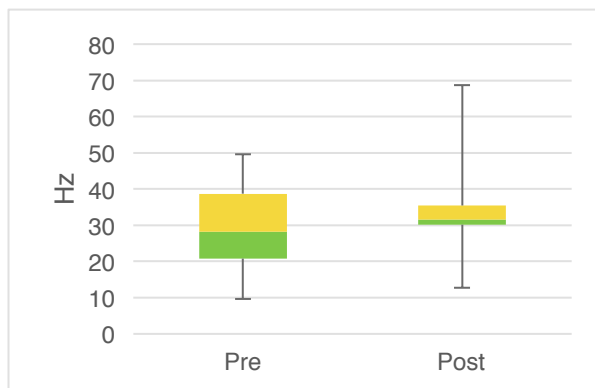


Fig. 36: Box Whisker plot Transmission:
User EEG affective response values pre- and post experiment intervention

Before	After	Difference
9.6	37.71	28.11
49.648	68.64	18.992
21.78	38.84	17.06
28.78	30.47	1.69
19.95	33.16	13.21
9.83	40.7	30.87
41.4	31.55	-9.85
26.44	29.94	3.5
36.05	31.71	-4.34
30.75	26.73	-4.02

Table 6 EEG Value Difference before and after Transmission intervention

Across Transmission's EEG data evaluation, the mean of all difference values \bar{d} equals 9.52. For the same set, the standard deviation of differences Std (d) equals 13.45. The standard error is calculated by dividing the standard deviation by the squareroot of the sample number (n=10). The standard error (SE) for the Transmission experiment, ergo amounts to SE=4.25. T equals the mean of differences (\bar{d}) divided by the standard error. This relationship is annotated as \bar{d} / SE . Dividing the mean of differences by the standard error (SE) of Transmission results in 2.24. For n-1, in this case 9 degrees of freedom, a lookup table provides the probability value of p=0.031 - for a two-tailed T-test. We can therefore assume with significant probability of p<0.05 that there is strong probability for a significant relationship between kinetic interaction and engagement levels with a confidence interval (CI) of 95%.

The **second hypothesis (H2)** assumes a correlation between interactivity and presence. Accordingly, the null hypothesis postulates no significant difference between the Transmission presence quotidian and the presence quotidian mean of the population norm. The difference in PQ quotidian between presence questionnaires derived from standard VEs and presence questionnaires acquired in the Transmission setup needs to be significant for the null hypothesis to be valid, or insignificant for the null-hypothesis to be falsified. The evaluation of the presence questionnaire resulted in a presence quotidian of 98.11. After correcting this quotidian by the standard error of Transmission, we statistically compare the result to the population norm using a Z-score test.

N0: $\mu = 104.39 \pm 15.78$
 N1: $\mu \geq 104.39 \pm 15.78$

Applied to the **z-test** formula, we can substitute the observed value of Transmission (PQ=76.73) with the PQ score of the UQO population norm. The expected value is also called population norm or the PQ score average. The observed value consists in the mean total of the Transmission presence questionnaire.

$$z = \frac{\text{observed} - \text{expected}}{S.E.}$$

As population norm, the UQO standard is corrected by its standard error. To synthesise research results, the Transmission mean total of 76.73 was calculated across all 19 questions, excluding any questions on sound and touch disregarded by the UQO validation. The standard error of 18.99 is derived from the standard deviation of the UQO norm divided by the square root of the Transmission sample (n=15), which equals 3.87. The standard error ergo equals 4.9 The Z-score for an observed value of 76.73 amounts to $Z = 76.73 - 104.39 / 4.9 = -5.64$. This value is outside of the range of statistic probability, indicating that the Transmission norm and the UQO norm are statistically

different, with a confidence interval of 95%. The null hypothesis assumed that the Transmission PQ is statistically indifferent to the PQ population norm. Regardless of the positive outcome of the intervention result, the experiment failed to create a true presence experience. Even though the presence quotidian falls into statistical proximity of the PQ score mean (91.1 minus its standard deviation is still above the sample mean) it is statistically unlikely that they conflate (Confidence Interval of above 95%). Transmission is thus measuring the impact of interactivity without measuring presence directly. Despite high construct and inner validity, the experiment failed to measure the intended dependent variable presence. Despite the PQ-evaluation indicating a perceived degree of presence, Z-score results suggest that the demonstration did not strictly qualify as a virtual environment. The results of the PQ make a statistically conclusive assumption on interrelations between interactivity and presence impossible. To achieve meaningful results, the research design would need to be adjusted, compensating for factors that reduce the impact of presence such as sound, the ability to move around freely or by providing larger screen interfaces. Another option would be to revisit the choice of presence questionnaire.

To summarise, I measured the effect of interaction on users of a brainwave interface, comparing EEG data output before and after a physical, kinetic intervention. The paired T-test investigated the effect and power of experimental intervention and tried to establish a relationship between presence pre- and post- kinetic interactivity intervention. The experiment determined with statistic significance (H1), that the intervention had a measurable impact on a group of users. A second quantitative analysis, failed to establish the perception of presence by this group (H2).

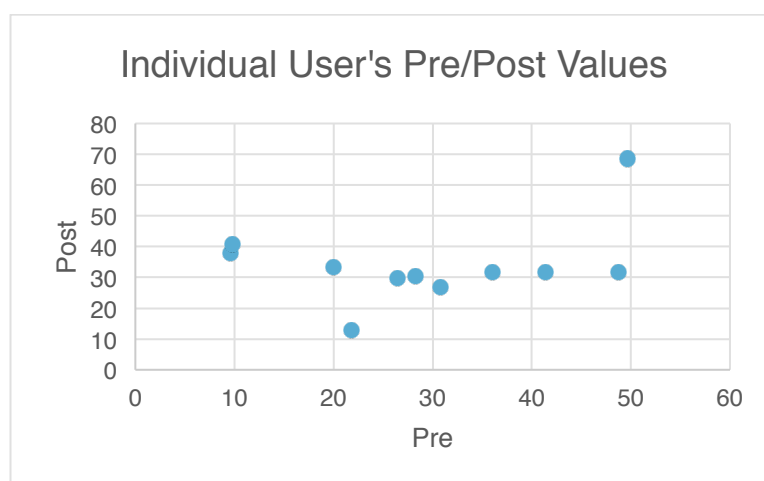


Fig. 37: Point plot Transmission

8.8 Discussion

As experiment, Transmission points towards the relevance of direct, bodily interaction and the impact that user interaction has on audience engagement. This becomes apparent not only in evaluating EEG data, but also through participant observation. Users are clearly seeing, feeling and reacting to external interaction with varying emotional responses and explanation patterns. The evaluation of EEG data further validates this assumption and shows that user interaction left a positive mark on audience perception. Audiences react to kinetic interaction with increased engagement, a fact that was measured with statistic significance. Within this experiment, brainwaves were perceived as virtual representation, but not as presence experience. This condition makes it impossible to link the effect of interaction directly to presence. Even though we can observe and measure the effect of user interaction on audience participation, we need to be careful not to confuse its impact with presence. Further technical improvements will be necessary to assure that Transmission serves as a presence interface in future research.

Despite difficulties to prove the link between presence and interactivity, research seems to support the evidence for a strong relationship between the two factors. Steuer (1995) cites vividness and interactivity as key components of presence. Presence research concentrated on kinetic movement (Slater, Usoh & Steed, 1995) as well as semantically accurate body movement (Slater, Steed, McCarthy & Maringelli 1998) as core components of presence. Witmer and Singer defined immersion as “psychological state characterized by perceiving oneself to be enveloped by, included in, and interacting with an environment that provides a continuous stream of stimuli and experiences” (Witmer & Singer 1995, p.227). The research conducted within the framework of Transmission points to a strong link between interactivity and brainwave activity, specifically user’s engagement levels. Transmission validated H1 - a significant effect of kinetic interaction on user engagement levels, but failed to validate the H2, a significant effect of kinetic interaction on presence. Controlling for other co-factors of presence, the case study was exclusively concerned with the impact of interaction on presence in respect of my creative practice. By virtue of such reductionism, the audio-visual experience was neither realistic, nor immersive in any way. The research design influenced the results of the presence questionnaire. As Transmission largely failed to measure intended results, the software design needs to be reconsidered in a repeated experiment to yield more conclusive research outcomes. A number of technical factors can be improved to facilitate a higher degree of presence - such as a more accurate representation, responsiveness, or a larger display environment. Entropy in visual representation needs to be reviewed. Alternatively, a different presence questionnaire could be used to measure presence directly. Further research will be necessary to ascertain the effect of kinetic interaction on user’s sense of presence, following an overhaul of Transmission’s research design.

8.9 Case Study Conclusion

The case study not only resulted in a functioning prototype for a new art piece -a brainwave-triggered motioncapture performance- it was also embedded into a wave of academic discourse on the intersection between art and neuroscience. Two symposia discussed synergies between art and brainwave computer interfaces (BCI) with contributions from researchers such as Hannach Chritchlow (Cambridge), Mick Grierson (Goldsmith University), Nillie Lavie (UCL), Gustav Kuhn (Goldsmith). Artists performing at the symposia included Luciana Hail (Sussex University), Rain Ashford (Goldsmith), Boredom Research and Anna Troisi (both Bournemouth University). The debate focused on questions of technical viability of EEG data, quantitative analysis (Mick Grierson and Tony Seiffert), historical technical developments (Luciana Hail) and artistic applications (Simon Kalynszki). Within the framework of these two symposia, the prototype for Transmission was developed and can now be refined for further artistic performances. The research overcame technical challenges such as latency, intuitiveness of use, as well as construct validity in assuring that signifiers represent what they are supposed to. Colour codes echoed emotional states, providing intuitive use for participants. Particle pace and saturation were triggered by user engagement. Participants were entering a dialogue initially with themselves, then with a secondary user. This interaction measurably augmented their user experience. Results of the case study were revealing on all levels: Participant observation proved the most sensitive technique to capture nuances and ambivalences of user reactions. Yet this real-time application failed to instill a real sense of presence.

The Witmer & Singer Presence questionnaire might not have been the best method in this context. The impossibility to examine the installation from multiple sides contributed to a low presence score, skewing overall results. Despite high values for realism and quality of the installation, key factors of the PQ slanted its outcome, making its use as an adequate research instrument questionable for this particular setup. Last but not least, the reliance on quantitative interpretation of data obscured the heterogeneity of user responses. Despite this danger of reductionism, statistical analysis provided intriguing results that could inspire future research in the field. With Transmission, the creation of a first, networked prototype, combining motioncontrol and brainwave monitoring was achieved. Presentations at Kinetica, EVA London and Siggraph point towards a large interest in artistic and academic communities to develop this project further.

Within the STM-framework, interactivity is defined by its components “directionality of interaction”, “active control” and “time”. The experiment confirmed hypothesis 1, a causal relationship between interactivity and user engagement, but failed to prove hypothesis 2, a direct link between interaction and presence. The research design although thorough,

would have profited from larger screens, better sound integration and a higher ability to move around the installation. Future research designs will need to provide a more conducive environment for presence experiences. Despite the failure to measure the objective of study, Transmission presents an important contribution to the discursive debate on presence, posing questions on effectivity of dialogue, on ability to control events through thought. Transmission proposes a new form of user interactivity as well as an entirely new performance concept. Furthermore, Transmission clearly verified the effect of interactivity on user engagement with a confidence interval of 95%.

As a case study focusing on the co-factor of presence in the context of my creative practice, Transmission investigated a very specific construct, controlling for the other two co-factors of presence realism or immersion entirely. Realism is the subject of the third case study. Just as much as Transmission exemplified the role of interactivity in presence experiences, KIMA demonstrated the role of immersion in virtual environments. Aura explores the concept of realism creatively and analytically. Aura consists in a telepresence art piece, as much as a case study of my research. As well as presenting the digital artifact, and its effect on users, Aura explores realism through expert interviews and a meta-analysis.

9. Aura – Subverting Realism as co-factor of Presence – Case Study III

As the third case study of this thesis, Aura discusses realism as co-factor of presence. Aura consists in a telepresence art piece on the one hand side, and a research project on the other. Both aspects highlight the complex relationship between presence, realism and properties of presence. Aura uses a mix of methods to question whether realism can be considered a co-factor of presence as suggested by the Standard Model, specifically in the context of Pepper's ghost. Realism in representation, not to be confused with the homonymous art movement, describes the objective to accurately reflect reality. Realism is understood as subjective evaluation of a virtual environment (Schubert, Friedman, Regenbrecht 2001). Realism is not identical with mimesis, the idea of imitating reality (Lyons & Nichols 2004), but implies the idea of objective, life-like and adequate representation. The school of verism, a genre of realism and an antithesis to euphemistic art was explored since the Ancient Greeks. Presence research and human interface design on the other hand adopted the term as descriptive concept for audio-visual fidelity to the real world. In this context, realism describes a technical condition, the idea of life-likeness, verisimilitude - fidelity of a virtual representation to its real world pendant. Realism is linked, but not limited to the visual image. The first case study, KIMA, presented realism as component of sound. The second case study, Transmission, showed that causality of interaction is an important component of realism. As third case study, Aura challenges the notion of realism even further by subverting its underlying concepts.

This case study looks at realism across seven different categories presented in the STM framework. These categories include technical dimensions -from image generation, to image transfer, to display- as well as psychological factors. In the tradition of Cochrane reviews, a thorough meta-analysis builds the methodological arch for this discussion. This meta-analysis is conducted formally through statistics as well as informally. A narrative analysis sheds light on realism in the specific context of Pepper's ghost. Expert interviews and a participant observation as well as the creation of an artifact provide further context. The presentation of the art piece "Aura" opens the discussion on role and significance of realism: Asking the hermeneutic, yet somewhat ironic question on limits of the concept, I wanted to shift the focus away from the domain of vision. Isn't realism in sound as relevant in virtual environments? Doesn't realism extend to invisible areas of perception? Where does realism start and where does it end? Aura questions the very idea of presence. Does presence require duality of interaction? Can we create a presence experience controlled by one self? What are perceptual limits of realism, and how does presence operate as a meta-physical concept? On a conceptual level, Aura, created in the context of generative art, raised questions on transcendence of self - the role of technology as substitute for spirituality and magic.

9.1 Aura – conceptual background

Aura creates presence on a holographic projection display, inviting viewers to connect emotionally with themselves. Reading participants' brainwave, Aura projects a personal imprint across a network. EEG data extracts user's empathic states and represents their individual conditions as holographic illusion on the Pepper's ghost display. The use of holographic projection plays on the dual nature of presence as spirit and as physical reality. Aura questions what it is to perceive someone's presence, creating a means of non-verbal communication for performance and installation. At the same time, Aura presents a technical take on telepathy, understood as communication "independent of the recognised channels of senses across a distance". Aura builds the third in a series of telepresence installations by Analema Group. As a case study, Aura offers a practical discussion of the role of realism in presence experiences. Arthur C. Clark's famous quote that "any sufficiently advanced technology is indistinguishable from magic" carries a lot of relevance in the discourse on art, technology, realism and presence. Conceptions of magic and technology have long been intertwined. For those unfamiliar with functionality of an apparatus, technology exudes an element of the mythical, a sense of magic. Audiences of a Pepper's ghost illusion uninitiated to the technology, tend to feel a sense of magic, specifically when first experiencing real-time communication on the display. Pepper's ghost is used as illusionist environment to create presence across large distances. Telepathy, as ultimate form of remote presence, becomes a conceptual canvas for this piece on realism.

The ideas of magic and remote control have been long interconnected: Magic quite literally refers to phenomena, remotely orchestrated through invisible forces. As Marcel Mauss explained, magic arises in the hiatus between wish and fulfilment (Compare: Stivers 2011, p.2). And yet trained magicians quite literally depend on technology, to stun their audiences (compare: Bhowanagary 1972, p.32). The word technology derives from the Greek word *techne* describing the arts of the mind, fine arts and crafts. Jacques Ellul defines technology as "the totality of methods, rationally arrived at and having absolute efficiency (for a given stage of development) in every field of human activity (Ellul 1964). Martin Heidegger differentiates between instrumental and anthropological use of technology - technology as means to an end, as well as a social practice. Technology comprises a set of instruments, methods and know-how that allow a collective to reach a specific objective, whether this is to produce, consume, to communicate or to distribute. The number of processes involved to reach such a goal is congruent with the level complexity of a technology (Gell 1988). Technology has a tendency to be seen as mythical: The more humans disenfranchise with technology, the more it is perceived as magical. Magic thus acts as symbolic bridge between technology and the objective, obfuscating techniques and know-how involved in an intended impact.

According to Malinowski, magic fills in the gap where technology is absent. The anthropologist Alfred Gell goes so far to claim, “if we no longer recognise magic explicitly, it is because technology and magic, for us, are one and the same” (Gell 1988, p.9). Malinowski famously described the Trobriand salt gardens, as a site of rituals and magic. The Trobriand Yam gardens were created in the belief of using magic, confounding technical processes with spiritualistic practices. In the eyes of the tribe, technology disappeared behind the rites. Magic provides a symbolic framework for codified techniques. Accordingly, magic can be conceived as the veil of technology.

But not only for consumers, magic and technology are intrinsically connected, interrelated phenomena. Futurist and anthropologist Genevieve Bell describes the early days of Silicon Valley as conjuring a vision that was both “manageable and magical” (Bell & Dourish 2011, p. 2) and asks for future development of spiritual technologies (Bell 2006). When Dr. John Pepper wowed audiences at the Polytechnic with ghostly apparitions in 1863, the immediate context was to demystify magic, in creating scientific spectacles. Presenters at the Royal Polytechnic relied as much on technology to create stage magic, as present day artists: Holographic showcases of Analema Group, Rachel Garrard or Madi Boyd instill a sense of magic among their audiences. At the Royal Polytechnic and beyond, the fascination with technology existed as two-way stream between artists, engineers and academics.

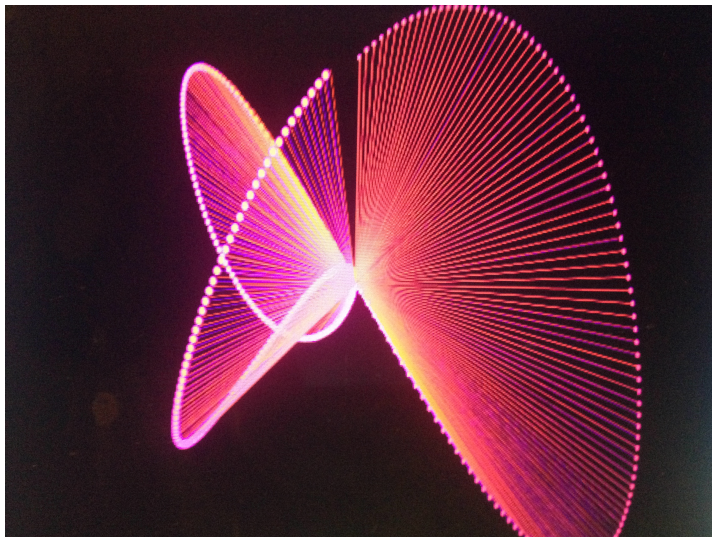


Fig. 38 Aura real time sculpture

As a technology with almost magical qualities, telepresence is a tool for spiritual quests - frequented by millions of individuals online. Taylor Shelton et al. mapped religious cyberspaces across the world. The tool “Prayer Companion” allows nuns to receive real-time twitter feeds from catastrophe stricken places, delivering online presence for prayers, where it is needed the most. Created by Interaction Research Studio in 2010,

Prayer Companion was presented at MOMAs “Talk To Me exhibition” (Interaction Research Studio, MOMA 2010). Wyche et al. at the Georgia Institute of Technology developed a praying card technology (Wyche 2009), which uses cards to pray remotely. But technology is often understood not only as a source, or a facilitator, but moreover a surrogate for spirituality. Evolution of technology led to innovations such as flight, telecommunication or indeed telepresence - considered to belong to the realm of magic by previous generations. Aura pushes into a new territory hitherto preserved to this field: telepathy as abstracted form of realism. This case study provides an overview on realism components in form of a meta-analysis on the topic, as expert-interviews discuss the subject in the context of Pepper’s ghost. But first and foremost, Aura is a telepresence art piece, playing on the intricate relationship between spirit and presence, magic and technology. Its discussion and participant observation provide further insight into alternate perceptions of realism.



Fig. 40: Madaleine Trigg: Sutre. Kinetica . Holographic Presence on Pepper's ghost display. Live performance. 2011 – photographer Jemima Yong Copyright 2010

9.3 Aura: Design & Technical Setup

Aura contrasts realism in remote communication, with an abstracted, stylised presence of spirituality. Telepathy is understood as means to transmit and transcend thoughts and feelings across time and space. With Aura, electroencephalography transforms brainwaves into meaningful imagery over a distance. Mapping brainwave frequencies to specific colours, Aura transcends thoughts across spaces in real-time – a different form of telepathy. Famously, Walter Benjamin evoked the image of an aura as “the distance of the gaze that awakens in the object looked at.” A metaphor for a radiating, incandescence of objects as a reactive, echoing effect (compare: Bratu-Hansen 2008), an Aura is the result of being studied and examined. The notion of parallax, of mutuality of gaze is central to the term, as much as its ethereal, spiritual quality. The art piece plays with this light-mirror analogy.

The term “Aura” can be traced back to the movement of spiritualism, and the esoteric publications of C.W. Leadbeater (1902). Leadbeater attributed meaning to colour across the visible colour frequency spectrum. In 1911, Dr. Walter J. Kilner speculated the human “aura” to be the result of mystic N-rays, a stance highly contested by the British Medical Journal. To this date, there is no evidence of an aura’s physical existence. Yet the concept remains nonetheless relevant, not only in philosophical debate: In psychology, auric perception is largely regarded as a synaesthetic phenomenon (Ward 2004, Milan et al 2007). However, researchers insist on conceptual differences between auric perception and synesthesia (Milan 2012). As metaphor of ethereal radiance, the concept remains persistent in philosophical, psychological and anthropological discourse.

For the installation “Aura”, the idea is evoked as symbol of reflection, a self-reflexive mirror of emotions: The user is wearing an EEG headset measuring their attention. This representation of self is projected on a Pepper’s ghost display remotely or in the same room. Users’ neurological activity is analysed by a Neurosky Mindwave EEG (neurosky.com). Registered signals are then transmitted as OSC messages on raw data, frequency bands and attention values. These values are projected as colours onto a real-time generated light sculpture on a Pepper’s ghost display. Mapped to specific EEG frequencies, the sculpture lights up in real-time according to input generated by participants’ brainwave spectrum. EEG data on user concentration is parsed to a MaxMsp based script via Bluetooth and interpreted in Processing (Processing.org) as colour code. The resulting light sculpture appears as delicate silhouette on the Pepper’s ghost display. Live telepresence feed and colour-coded, auric representation are amalgamated providing users with a real-time representation of their cognitive state of mind. Aura transmits feelings across time and space, a form of telepathy as holographic projection.

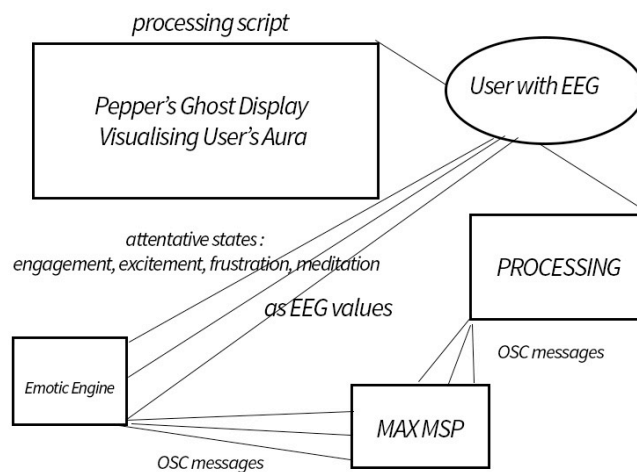


Fig. 41 Aura – Technical setup

Pepper's ghost acts as interface to a different location, a mirror for interaction and passive reflection. Wearing the EEG headset, users' emotions are captured and interpreted remotely. As technology disappears behind the process, presence is perceived as meditative and reflexive inside the holographic display. Self-reflection or concentration changes this "aura" in real-time. Communication as a spiritual, emotional experience borders on telepathy, as users' mind is being read "independently of the recognised channels of our senses".

Aura is not only designed as art project, questioning the effect of remote presence on our senses. Aura is also a research project: The art installation was followed by participant observation, expert-interviews and a meta-analysis. Assuming realism in representation is positively linked to presence, this hypothesis is first explored qualitatively through participant observation. In addition, realism as co-factor of presence is explored quantitatively through a Cochrane-Style meta-analysis as well as through expert interviews. This triangulation of methods guarantees a multi-dimensional perspective on the phenomenon. Whereas analytical methods discuss realism in its physical qualities, the art piece subverts this notion: Conceptualising realism as truthfulness to the real world, Aura represents non-visible qualities of reality. Viewers perceive telepresence as a trigger for engagement, a mirror into their own soul. Aura was presented to audiences at Festival of Learning 2015 in a therapeutic context - as a potential tool for shock treatments, for trauma victims or occupational therapists. Subsequently, Aura was presented as digital art piece at Kinetica's Gravity show 2015 in Central London. Large exposure, audiences of up to 3,000 people, and a high degree of interest point to the relative success of the piece. The next chapter presents Aura through the lens of participant observation in the context of my creative practice.

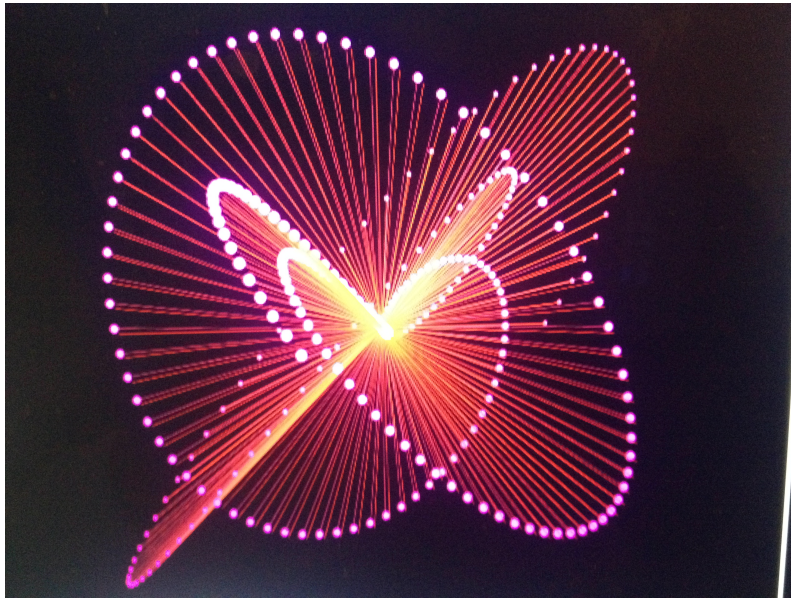


Fig. 42 Aura at the Festival of Learning 2015

9.4 Participant Observation - Aura

Whereas the KIMA-case study questioned immersion as component of presence, and Transmission avoided immersion as much as realism in depiction, the third case study “Aura” concentrates on presence as non-interactive and non-immersive installation.

Aura was presented to audiences as a networked interface, entirely self-referential on a front-on display. First displayed publicly at the Festival of Learning at Bournemouth University and then at Kinetica’s Gravity show in November 2015, it is staged on a small-scale Pepper’s ghost display. The Festival of Learning featured pieces by CDE colleagues, Asha Bleatherwick, Max Moseley and Phil Wilkinson, and was aimed at audiences from the Bournemouth and Poole region. Art was exhibited in the context of people with “(dis)-abilities”, i.e. minority groups with learning or senso-motoric difficulties. The showcase attracted an audience of about 40 people over two evenings, including professionals from social care-services, occupational therapists, educators, academics and people from the arts.

Kinetica’s Gravity show on the other hand, was curated by the artist Dianne Harris at London’s “The Hospital Club” in Covent Garden and featured artists such as Lianne Lijn, Chris Levine, Paul Friedlander, Balint Boygo and UBIK. Analema Group’s Aura was displayed as a stand-alone Pepper’s ghost sculpture. Visitors were invited to wear the EEG headpiece and to experience Aura interactively. Over three days, visitors of all ages and backgrounds discovered the interactive possibilities of the piece.

Aura's creative code derived directly from Transmission, yet resulted in an entirely different visual outcome. An ever-changing doublehelix moves slowly around its own axis. The amount of nodes is defined by participant's attention, which also influences the sculpture's pacing, colour, and saturation. Participants channel their concentration -be it through sound, mathematic computation or visualization- to observe their mind in real-time. Aura presents participants with a mirror into their personal headspace, different for every user. An inner dialogue ensues. As participants reflect on themselves, their Aura transcends into a physical light form - creating a presence of thought. In the absence of sound or controlled lighting, Aura is by no means immersive. As a mirror into oneself, Aura avoids any interactivity. Aura was designed to control for other co-factors of presence as described in the STM-framework. Aura creates a sense of presence, by relying on a different form of realism: What viewers see is as real as could possibly be: Brainwaves exist, they just happen to be invisible. Aura bridges the gap between a pragmatist fascination with the invisible and a pragmatic approach to realism.

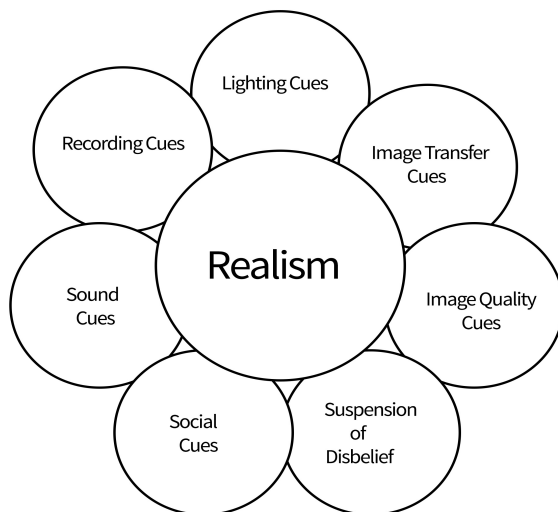


Fig. 43: STM-Cues for Realism

Participant observation relies on a conceptual framework, and its discrete units of analysis, which allow for an inductive method of theory building. In the case of Aura, the STM-framework builds the analytical reference model. As qualitative method, participant observation has been popularized by Bronislaw Malinowski – specifically as a type of field research instrument for cultural anthropology (Jorgensen 1989).

The field for this case study consists in the context of its display, the gallery space, as the forum for discourse with the wider public. Kinetica's Gravity show, produced by Kinetica founder Tony Langford, provided Analema Group with an ideal field for this research. Not only was the audience diverse, as a gallery show, Kinetica facilitated public discourse, providing an opportunity to test the hypothesis -of a direct relationship between realism and presence- in a live setting.

As a researcher, I acted as moderate participant. Expediting the interaction with the art piece, I entered into dialogue with the audience. Yet I retained the role of passive bystander, a facilitator, explaining “Aura’s” functionality to the public. Taking part in an active debate on effectiveness and functionality of the piece, the discourse itself was personal and almost intimate. Questions were concerned with individual triggers of attention, causes and strategies to improve participant’s focus. Here, realism is understood as plausibility, believability of the virtual reality - its representative quality to reflect an inner truth. Individual’s attempts to manipulate the Aura light sculpture through their minds represented users’ ability to focus. This form of realism went beyond mimetic imitation. Participant observation utilizes discreet units of analysis for discussion of the field work- in this case derived from the STM-framework:

Recording Cues: After employing Epoc’s “Emotiv”-EEG at the Festival of Learning, Aura was further improved by adapting the script to the Neurosky’s “Mindwave”-EEG headset. Despite relying on a single-node contact point, Neurosky headsets detect concentration in the ventral-fronto lobes. This guarantees accuracy in measurement of user attention. The opensource MaxMsp-software BrainwaveOSC sends correlating data to a Processing-patch, which maps concentration float values onto the light sculpture. Developed using opensource Processing scripts as basis, the software was adapted to reflect the creative vision of this piece. Neurosky’s hardware and BrainwaveOSC MaxPatch are performing in near real-time with a negligible delay of 1fps. Users “connect” to the installation in putting the headset on, with immediately visible results: The sculpture changes its colour, virtually coming to life. Participants reacted well to this initial point of recognition as it provided impromptu gratification on functionality. Brainwave representation was symbolized on a “What you see is what you get” WYSIWYG-type interface, resulting in fidelity to an invisible, yet personally tangible reality.

The vast majority of users reacted with sincere and earnest communicational examination, not only of the technology, but more so themselves. Hardly any user questioned the technology: EEGs are reasonably familiar sights. Yet the majority, more than 150 over the four days of the Kinetica installation, spend a significant amount of time “listening” to their inner cognitive sensitivities. Trying to understand “what makes them tick”, participants were in search of factors that aid their concentration. Whereas some started to hum, others were using mathematic operations to stimulate their brain activity. “Aura” administered a sense of introspection, an inner dialogue, culminating in a new form of realism, a new form of presence.

Lighting cues: Aura was presented on Musion’s Eyecandy unit, a smaller sibling of Musion’s “Eyeliner”. Eyecandy has the dimension of a standard screen size i.e. about 40”

in diameter, and in this case was presented at eye level with an open back, enabling visitors to see through the holographic sculpture onto the backwall of the gallery space. Lighting from within the unit reflected onto the wall behind it, creating a backdrop to the rather theatrical environment. Next to the piece, Paul Friedlander's mesmerizing light sculptures reflected on two adjacent walls. Lighting was not used as an instrument of spatial, immersive qualities, but rather a functional tool. Separating the light sculpture from the screening device, it created necessary depth cues for 3-dimensional perception of the spatial environment.

In this instance, light was not only employed as a contextual, ambient backdrop, but rather created the sculpture itself. Coloured light painted in the form of an intersected double helix, a 3-dimensional infinity sign, provided the audience with an interface to their own "inner" world. Here, realism was inherently linked to causation: Light was perceived as realistic, if its functionality was given, and the emitted colour represented the anticipated concentration tendency accurately. The vast majority of users gave the installation the benefit of doubt. The audience spent time to understand not only responsiveness of the piece, but also their own ability to concentrate. The resulting dialogue was not a technical discourse, but deeply psychological, almost intimate introspection. Participants associated colours with concentration level rather intuitively, and accepted their symbolic character.

Image Transfer: Functionality was assured through of a chain of different scripts: The signal was relayed via the headset's Bluetooth sensor, transmitted to a Max/MSP program, then sent to a Processing-script, which interpreted the values onto the Pepper's ghost display. The computer was connected to the Pepper's ghost interface via HDMI cable. The delay resulting from the complicated image-processing pipeline was nevertheless low with about 1second in total. Framerates varied between 30 and 60fps. Research by Sylaiou et al. (2008) and Meehan et al. (2003) indicates a significant, yet inverse relationship between presence and high latency. Participants seemed to overlook and accept latency as minor, technical artifact. The idea of causation, of cause and effect between concentration and visualisation was transcended successfully.

Image quality: The piece was presented as an abstracted image. Representation was therefore less mimetic, imitative and more diegetic, narrative. Image resolution was full HD and the image was bright enough to be perceived from all angles as a free-floating light sculpture. Audience members reacted positively to the visual impact of the piece.

Sound Cues: No sound cues were presented with this piece to control for any immersive factors.

Social Cues: The depicted form of presence referred to a single, ontological construct, participants' concentration. Subjects exhibited a strong sense of familiarity, almost intimacy with the interface. Their inner excitability, their propensity to react nourished the colour code of the light piece. Technology receded to become facilitator of a solipsistic, self-centered experience. As a post-cinematic re-enactment of Lacan's mirror analogy, Aura prompted a dialogue between participants and their cognitive receptivity. Realism was created through image fidelity to momentary, time-based neurological processes.

Suspension of Disbelief: The vast majority of participants eagerly accepted the highly abstracted kinetic sculpture as representation of their cognitive processes. Generally, EEG data representation tends to disclose brain activities in a very abstracted manner – a fact that nourished participants' endorsement of the piece. Initial attempts pair the piece with photorealistic representation on the holographic projection, be it through mirrors or cameras, risked to fall into the "Uncanny Valley" (Strait 2015, Seyama 2007). Although the piece required personal engagement with one-self, participants displayed an eagerness to explore technical and visual potential of the piece. The majority of users was prone to suspend disbelief, and accepted Aura as presence construct - a mirror of their cerebral status quo.

The display of Aura ignited a wider debate, on limits of realism as phenomenon that can reach beyond the visual. Our perceptual reality includes abstracted concepts, questions of causality (Cavazza 2007), functional relevance, and plausibility. The audience's reaction reflected a genuine sense of engagement. An active discourse between holographically projected image and their inner self heralded a new form of presence - one that goes beyond visual emulation of reality. Aura illustrates a paradoxon in the conception of realism itself: Can realism consist in mere causal provenance? Is something less real because we cannot see it? Aura investigates the possibility of non-visual mimicry, of alternate forms of presence.

9.5 Expert Interviews

As part of a closer investigation of realism on Pepper's ghost, I conducted a small intervention in a controlled environment at the Musion headoffices at Westcott House, Portland Place in August 2014 prior to the development of Aura. A small number of experts were invited to judge realism factors side by side. Images were recorded in the Musion telepresence room, and compared one after the other, for an expert audience to judge. Specifically, realism factors pertaining to the standard model such as image recording, image transfer lighting, social cues, were compared against one another. A select panel of nine experts was invited to cast their judgement on factors of realism. Specific test items were pre-recorded on a Sony EX-3 camera as uncompressed video

stream, and displayed on Musion Eyeliner display. Only minimal postproduction was applied so not to influence the production process and to avoid skewing results. Panelists were evaluating realism factors one at a time. Upon entering the Pepper's ghost theatre, questionnaires were handed out. Participants were invited to compare two clips side by side and to rate effectivity of these individual factors on a 7-point Likert scale. All experts were asked to mark comparison pairs, for their impact on stage presence and realism. Only one image attribute had been manipulated, all other factors were controlled for. Questionnaire data was then correlated in a student T-test. P-values were calculated for all 8 factors.

Participants were recruited directly from the pool of holographic experts from within the company with extensive experience in Pepper's ghost and a trained eye for holographic representation. Eight factors were compared, shown one after the other in pairs of two. Audience was given enough time to judge between two comparison images. Out of eight evaluated comparison factors, six showed significance of impact on realism and presence:

Exposure: Comparing image-recording factors, experts were invited to judge an image with subtle exposure compared to an image that was slightly over-exposed. As Pepper's ghost imagery relies on the display of black colour values within ambient lighting conditions on the holographic stage, over-exposure is a frequent condition. Experts' opinion on overexposure however was unambiguous and clear-cut. Unisono, experts disliked an image over-exposed image by one stop, and preferred an adequate exposure rate.

Lighting / Shadows: The next cluster of questions was concerned with lighting. Here, results were contradictory to literature review and meta-analysis results. Contrary to Rademacher's seminal study, experts were unable to measure a significant effect of either soft or harsh shadows on realism. The panel was confronted with two samples: The portrayed subject matter was filmed twice, once in a light situation that used filters to soften the shadows, once with harsher shadows. The small recording studio might have influenced lighting conditions and with it the research results to a degree. The small space of three meters in width and five meters in depth, was equipped with reasonably planar, diffuse lighting (LED panels). Also statistically non significant was the comparison between harsh edges and softer edges of the shadows. Again, it is possible that overall diffuse lighting in the small environment might have influenced the outcome.

Image Transfer: The third test item concerned image transfer methods. In this example, the same image was played back in two different ways: Once using HDSDI cables (12bit) and once using DVI cables. In this scenario, the use of HDSDI cables was preferred,

possibly due to the use of a better graphics card (AJA Kona) and the higher transfer bitrate. Considered a quality of image transfer, questions of latency and delay can be one of the prime artefacts in Pepper's ghost display. As shown by Styliani Sylaiou (2010), latency, lag and delay play a significant part in the successful generation of presence. Initially, a piece with audio-video synchronicity was compared against a video with a marginal video delay of 2 frames. Experts attested a significant difference between the two examples. In another test on temporary image transfer factors, experts interrogated the relationship between framerate and presence. Meehan et al. (2002) proved a significant dependency between framerate and presence. In this experiment, experts unequivocally preferred a higher framerate of 29.97 frames per second (fps) to a lower framerate of 25.

Image Display: The fourth test item investigated image display, or in this case the effect of texture complexity. Image spatial frequency was created through the texture of the presenter's outfit. Evaluating the impact of different patterns created an instrument to measure the effect of spatial frequency on the audience. Johnson et al. (2010) identified spatial frequency as key-contributor of presence. A significant majority of experts reported a visible difference in realism perception for the outfit with a more complex pattern. This result is in line with research by Shaojin Fang et al. (2011) on the effect of spatial frequency on realism perception.

Social factors: Last but not least, the one-sided T-test demonstrated a significant relationship between familiarities of the subject to a non-familiar subject matter. As postulated by Lane Philips (2012) a personal relationship and familiarity with the environment plays a distinctive role in presence design. The expert panel confirmed this circumstance for the context of Pepper's ghost with statistically significant probability. Despite a relatively small sample, unambiguity of results (Confidence interval of 95%) provides important indicators to the understanding of realism perception on Pepper's ghost as opposed to other virtual environments. Lighting, the only factor with results that showed no statistic significance, serves a different role on Pepper's ghost compared to other virtual environments. Lighting sculpts, shapes and paints the virtual image through projection into space, but also builds its environment.

On six out of eight evaluated realism factors, the expert panel reported a visible, statistically relevant difference. The difference was most noticeable and distinctive for latency - followed by framerate, signal transmission choice and last but not least familiarity with the presenter. Pepper's ghost test results largely coincided with presence research literature. The only deviation from domineering research concerns the effect of harsh and soft shadow intensity as well as harsh and soft edges of shadows. This points to the very complex role lighting plays in the context of Pepper's ghost and warrants

further research in the field. Research results are tabulated and presented below as well as in the appendix. The results of this test subsequently influenced the production of the Aura artefact. Future research would profit from a larger sample and a control group.

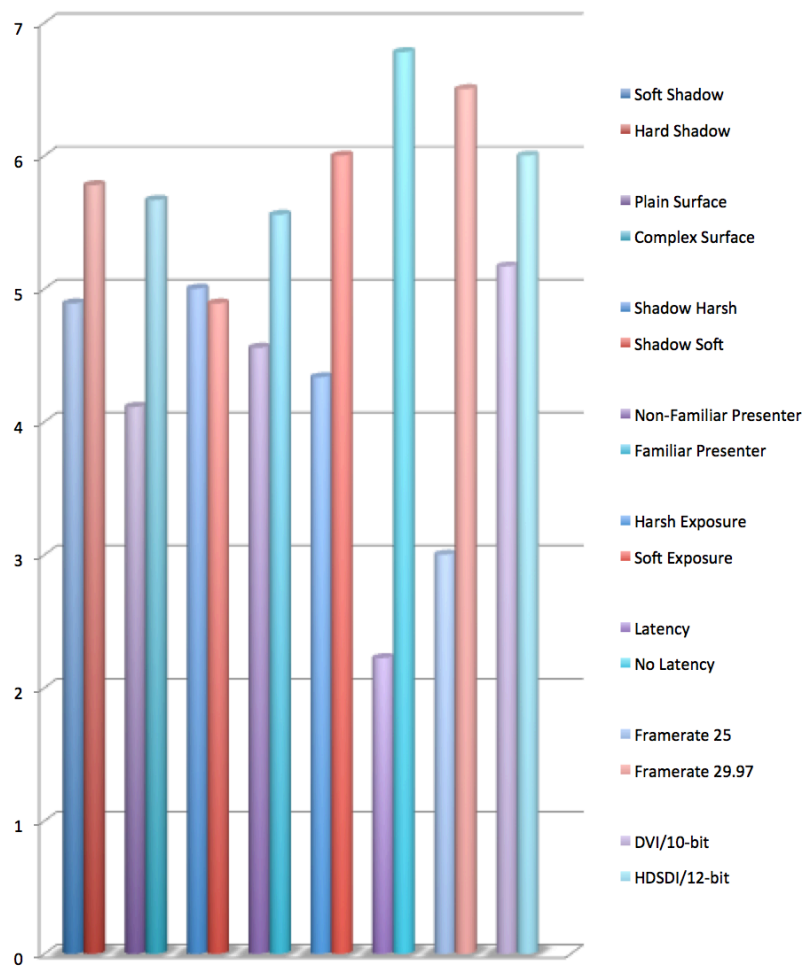


Fig. 44: Graph - Expert Interview results and probability values

9.6 A Meta Analysis on Realism

Virtual reality environments aim to evoke presence through a range of different audio-visual strategies. The STM framework links presence to three co-factors, immersion, interactivity, and realism, independently contributing to presence experiences through a number of underlying audiovisual cues. A degree of academic consensus supports the hypothesis that realism plays a specific role in presence creation and presence perception. Sheridan (1992) Held & Dulach (1992), Witmer & Singer (1994) cite realism as a key component of presence, Bouchard (2010), Shafer et al. (2014) and others expanded extensively on the subject. A number of relevant studies within telepresence research focused on realism, the role of display resolution and display quality (Wood, Griffiths, Chappell, & Davies 2004; Shapiro, Pena-Herborn, & Hancock 2006,

Rademacher 2002). In the context of virtual environments, realism is often understood as a subjective evaluation of the virtual environment (Schubert, Friedmann & Regenbrecht, 2001). Slater related indicators of presence experience to the real and everyday (Slater et al. 1994). Sheridan in turn linked presence directly to the perceived degree of realism within a virtual environment (Sheridan 1996). Bracken compared HD and SD signals and their effect on perceptions of presence in news broadcasting (Bracken 2006, p.723-741) sound, lighting, transmission standards and recording cues feed into the wider debate on how realism affects presence experiences. A wide range of literature investigates different angles of the phenomenon, factors of image recording, generation, transmission, display and user perception. This study critically evaluates the existing field across key categories as layed out in the Standard Telepresence Model through both informal (contextual, descriptive) and formal (statistic, numeric) meta-analysis. These research results are subsequently converged with qualitative participant observation of the Aura piece, as well as expert questionnaires in the context of my own creative practice. The meta-analysis builds the core of this case study.

A range of studies examine the relationship between realism and presence experiences: Previous attempts in a comprehensive (both formal and informal) meta-analysis of the field were conducted by Nick Yee, Jeremy N. Bailey (2007) et al. at the University of Stanford – with a specific focus on the relationship between anthropomorphism, realism and presence. The strength of this meta-analysis lies in its specific emphasis on a clearly defined subject matter. Also at Stanford, James Cummings, Jeremy Bailenson and Mailyn Fidler's study "How immersive is enough?" investigated the effect of immersion on measured presence. This descriptive analysis engages in a thorough literature review, identifying key components of immersion. In both cases, a meta-analysis provides an overview on relevant research in the field, furthermore identifying a weighted status quo in their respective results.

Before condensing existing research on realism in presence experience, the phenomenon needs to be critically conscribed. An overview of existing studies indicates the heterogeneity of the phenomenon. Realism in animation displays a different level of abstraction, than filmic representation – yet both follow the same rationale and objective: Realism strives for an approximation of real-world experiences in virtual representation through simulacra of technical and subjective conditions. The definition of realism in the context of VR remains a controversial subject, with attributes ranging from fidelity, to plausibility, from similarities with real-world environments, to accuracy in representation. Terminological incongruencies are paired with questions on the boundaries of the phenomenon. What constitutes realism seems to be influenced by a range of contextual, behavioural, psychological co-factors: Can fidelity of emotional representation (i.e. in the Aura setup) be regarded as realism, despite its invisible and visceral characteristic?

Should a study on accuracy of brainwave representation be included in a meta-analysis on realism? These and other questions precede any literature review, any evaluation of formal or informal meta-analysis. This meta-analysis excludes extreme outliers of the phenomenon, concentrating on seven key constructs as defined by the Standard Model. All of the selected studies were conducted within an experimental research design. All of the studies were quantitative in essence, and provided a degree of inner validity. All studies were discussing the same constructs - realism and presence experiences. Studies of only qualitative, mathematic, or analytical nature were excluded for sake of homogeneity and intercomparability.

Objectives

This meta-analysis seeks to summarise and to present an overview of existing research on realism as core component of presence in VR systems. Realism defines how similar a synthetic reality is to either the human visual perception or a virtual representation of the same scene. Components of realism are analysed across seven key factors of the STM framework: Recording cues, Lighting, Image Transfer, Image Quality, Sound Cues, Social Cues and Suspension of Disbelief. This meta-analysis excluded any purely qualitative research, studies relying entirely on self-report, or studies without any significant construct validity. Given a very heterogenous field, only studies linking presence to realism were selected. The definition of realism in the context of VR remains an operational one, trying to combine technical, perceptual and contextual factors. On a broad general level, the research question is interested in the relationship between presence and realism and whether this link can be proven with statistic probability. The meta-analysis compared 37 studies out of a catalogue of 72 pre-selected studies informally and 6 studies within the formal meta-analysis.

Hypothesis

Previous research in the field, suggests an observed effect between realism and presence. Presence research has long distinguished between subjective and objective measures and has postulated a measurable effect of realism on presence. This meta-analysis looks at a large body of studies to analyse whether this effect can be measured with statistic probability. We assume a direct effect of realism on both reported and measured user experiences.

H1: Realism as described within the Standard Model can be seen as a direct component of presence and has a measurable effect on presence.

H0: Consequently, we can build the null-hypothesis, stating that realism has no statistically measurable effect on presence.

Search Methods

Considered for inclusion in this search were studies from the field of presence research, virtual reality, psychology, computer graphics, and media-arts. The search method covered the Bournemouth University Library catalogue (15th September 2014, 22, April 2015, 3rd of July 2015), including JSTOR archives, Leonardo, Presence and the Cochrane Library (2015, Issue 3), as well as the ACM Library, Google Scholar, and the IEEE catalogue.

Selection Criteria

Only studies with an experimental focus were included in the review, and only studies published in a peer-reviewed publication or conference proceedings were considered for inclusion. 72 studies demonstrated relevance to the subject matter with variable degrees of methodological integrity, reliability, and construct validity. A certain number of publications demonstrated missing data, making the generation of effect sizes impossible. Studies with no quantitative components had to be disregarded, and studies with a purely data-driven, mathematic-analytical approach were also excluded. This resulted in a final master catalogue of 37 studies for the informal analysis. Out of these only 6 studies fulfilled all criteria required to be included in the formal, statistical part of the meta-analysis. The research includes randomized as well as non-randomised studies with a minimum sample of 4 participants. Papers with high risk of bias were excluded from the meta-analysis.

Data Collection and Analysis

All data was collected systematically, attributed to an STM cue category and analyzed using mean difference and confidence intervals of 95% wherever possible. Where no comparable studies were available, the data was analyzed and reviewed independently. The study review is split into an informal descriptive part, and a formal systematic part. Evidence quality was assessed on a case by case basis per study, and the effect was weighed through the effect size and the correlation coefficient r . Every study included in the analysis was coded with formal and informal methods: Formally, sample size, standard deviation and mean, and publication year, effect size and probability value were coded. Data was standardized, synthesized and evaluated for all 37 studies included in the informal analysis. Informally, the method, the experimental setup, and the key results were transcribed and tabulated according to the standard model. This structure was then used for a narrative analysis of realism factors in the context of Pepper's ghost. The study is presented in two parts: The formal, statistical evaluation is followed by an informal, discursive analysis of the relevance of study results in the context of Pepper's ghost.

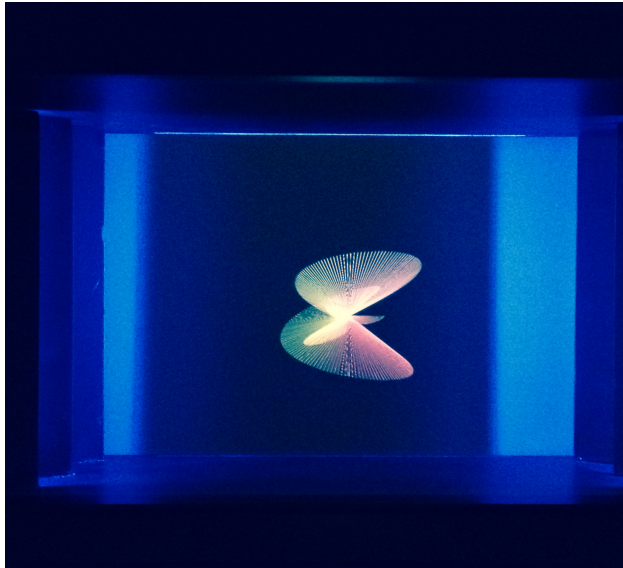


Fig. 45: Aura at Kinetica's Gravity Show 2015

9.7 Realism Meta-analysis – formal analysis of Realism factors

Method

Meta-analysis offers a statistic research instrument for the evaluation of data across independent studies evaluating a single construct. The background of meta-analysis is often clinical, with precise data on effectiveness of an intervention (treatment) at hand. The dependent factor investigated is presence, realism being the independent variable. The research question of this case study investigates whether there is an intrinsic link between realism and presence. The hypothesis of this case study, formulated within the standard model, is a fundamental relationship between realism and presence. Building the null hypothesis of no existing statistically relevant relationship between realism and presence, this meta-analysis looks at a large body of studies, concentrating on the prevalence of such an affiliation. The danger of any meta-analysis is selection bias, specifically when concentrating on a narrative, informal analysis alone.

Types of studies

The standard model describes seven key dimensions of realism in the context of presence research. In the informal part of the meta-analysis, 37 studies were tabulated according to these categories, together providing an overview on the status quo in the research field. Meta-analysis brings together different study results, aggregating and synthesising findings to produce a single estimate. Not all studies selected for informal, narrative meta-analysis met the criteria for a formal, statistical analysis: Not only were some of them measuring different dependent variables (Depth Perception, Performance), not all of the studies demonstrated significant reliability, validity or objectivity.

For the formal meta-analysis, only studies concentrating on the factor of presence were selected, all other studies were disregarded. This further decimated the pool of relevant studies. Research by Rademacher et.al (2001) for instance, an important contribution on realism in the context of design was excluded from formal analysis, on grounds of measuring a different trope. Due to a very conservative reading of formal criteria, the final catalogue of studies included in the statistic meta-analysis was limited.

A meta-analysis by Nick Yee, Jeremy N. Bailenson and Kathryn Rickertson (2007) of Stanford University, investigates the effect of human avatar realism on user experiences. Their study shows a narrow research focus. The remit of this case study is wider, comparable to Cummings, Bailenson and Fidler's meta-analysis on immersion and presence (Cummings, Bailenson and Fidler 2012). To create a comprehensive overview - less reliant on data constructs, than on meaning- this study is split into a formal and informal part. The informal, more descriptive analysis applies research results to the specific contextual application of Pepper's ghost.

This case study's formal meta-analysis condenses the master candidate catalogue. Only a handful of studies passed a stringent quality assessment procedure: A priori, all studies with low reliability, missing statistical data or poor construct validity were excluded. A number of studies were missing data on standard deviation or effect size – specifically Cavazza et al. (2007), Freeman and Lessiter (2001) and MacMahan et al (2008). Although all of these studies focused on presence as dependent variable, they failed to disclose information required for statistical meta-analysis. Out of 37 studies included in the narrative analysis, only a total of six were included in the formal evaluation. Their average year of publication was 2004.5, with a standard deviation of 8.5 years.

Types of participants

The total number of subjects included in this meta-analysis amount to 249, with an average study sample size of 37 (SD = 18.38) and an average age of 24.7 years. Not all data on gender distribution was available: The gender ratio for five of a total of six studies points to a total of 66.43% male participants, with an average age for females of 33.57 %.

Types of interventions

Only experimental and quasi-experimental research was included in the study. A large corpus of research presented in the initial catalogue did not disclose methods of subject randomization. Only studies with presence as a dependent variable and realism as independent variable were included in statistic analysis. Five dimensions of the standard model are represented. Despite a large number of published experiments, academic rigour, completeness of reliable data and construct validity was not always evident. Although the totality of studies in the initial catalogue was peer-reviewed, not all research

met quality standards required; More often than not, study data was inconclusive and results of research repositories not satisfactory. Consequentially, the amount of studies investigating the phenomenon via quantitative data was limited. Research in realism can largely be categorized into behavioural measures and subjective measures. Discussed studies fall into both categories, with the vast majority -six out of eight- relying exclusively on subjective measures.

Types of outcome measures

Studies described a range of different data idioms and research results. Numerical normalisation of effect sizes of such diverse fields as lighting, image transfer, social behavior or sound is problematic due to the heterogeneity of data sets and diversity of the research. Yet all six studies measured the effect of realism on presence.

The evaluation concentrated on data originating from diverse research instruments such as presence questionnaires, surveys or biometric research. The generation of data can be regarded as diverse as realism factors they refer to. Meta-analysis combines data by measuring the effect size of studies, i.e. weighed data sets, defined by a number of different standardizing methods. Meta-analysis measures a global effect magnitude across several studies with a specific confidence interval (Huedo-Medina et al. 2006). In this process their respective heterogeneity becomes important.

The most common of effect size measures is Pearson's product moment correlation coefficient, which indicates the direction of a correlation, by measuring the degree of interdependence between two constructs. In meta-analysis, the weighed value of r determines the effect size of a study and is measure-unit independent. According to Cohen's effect size conventions a factor of $r \geq .10$ is considered small, a factor $\geq .30$ is considered medium and a factor $\geq .50$ is considered large (Cohen 1988). Standardising the effect size of individual studies with either the number of subjects (sample size) or more accurately with the inverse variance weight, and evaluating the standard effect mean across a number of studies, we can determine the power of the effect size across these studies.

Hypothesis

The research interest of this study can be formulated as the objective to establish a statistically significant effect of realism and presence. Looking at a meaningfully large number of eligible studies (sample size of $N= 259$), we can relate realism factors directly to presence with a specific certainty. Existing research suggests a strong interrelation between realism factors and presence perception (Insko 2003, Youngblut 2003, McMahan 2012, Khanna et al 2006). Yet the topic remains subject of much controversy: Dinh et al. (1999), Cho et al. (2003), Zimmons & Panter (2003) challenged the position of

a positive dependency between these variables. Following a comprehensive literature review, synthesizing data across a large body of research, there seems to be strong support for the hypothesis of a link between perceived realism and subjective experiences of presence.

H1: The effect of realism measures will have a significant effect on individual presence perception. $H1: r \geq .30$

H0: The null hypothesis assumes no significant relationship between realism and presence perception. $H0: r \leq .10$;

Procedure

Studies selected were distilled from the master candidate list, itself the outcome of an extensive literature review of 76 eligible studies. This initial candidate list was derived from the ACM library, the IEEE catalogue, JSTOR and Bournemouth University's catalogue of journals and papers. Of these 76 studies, 37 studies were using experimental research and had been published in a peer reviewed journal or a conference proceeding. These 37 studies were included in the master catalogue and analysed during the informal, descriptive part of the study. Out of 37 studies of the master catalogue, ten concentrated on presence as evaluated variable with realism as independent variable. The remaining studies providing required statistical evidence, standard deviations, i.e. R-values or Control group sizes, to permit direct comparison across different factors totaled six.

The six studies included in formal analysis refer to different factors of realism. Two papers refer to recording factors: Ling, Nefs et al. (2013) evaluated the effect of mono and stereo viewing on realism. In their study "The Effect of Perspective on Presence and Space Perception", the authors used a presence questionnaire to evaluate the effect of parallax, vantage point, but also of binocular versus monocular viewing. The results indicate that field of viewing mode, field of view, the center of projection all affect presence. Ling's in-depth analysis correlates a number of different factors, including realism and presence. Results confirm that presence increases with monocular viewing compared to binocular viewing. Presence also increases when the vantage point of the audience is at the center of projection. Life-sized virtual presence is perceived to show a higher degree of presence than scaled-down versions. Different display environments (TV-screen or projected image) result in different degrees of presence with a higher degree attested for projection, possibly because of larger overall image size. The effect of a larger screen size on presence was confirmed by the study.

The second study of the master catalogue relating to recording factors, discusses the importance of 3d spatial cues for the generation of presence (Styliani Sylaiou et al. 2008). A total of 46 participants tested the relevance of 3D-spatial cues in the generation of

presence at the University of Thessaloniki. Despite missing complexity of employed methods, research results suffice all relevant criteria to be included in the meta-analysis. According to Styliani et al. 3-dimensional spatial cues contribute to perceptions of presence. The effect size of the study is derived from graphs presented in their publication. The study by Katerina Mania and Andrew Robinson (2004) discusses the effect of lighting in renderings on perceived presence levels. Conducted at the University of Sussex, this study points to the relevance of high quality lighting in perception of presence with a sample of thirty-six participants and an effect size of $r=0.54$.

Meehan, Insko et al. (2002) discuss the importance of frame-rate, multiple exposures and passive-haptics on presence. As factor of realism, framerate was tested for different magnitudes and correlated with presence. Using heart rate and skin conductance along with a presence questionnaire, Meehan confirmed a monotonical increase of presence with higher framerate. A landmark study by Davis, Scott et al. (1999) discusses the role of audio in virtual environments. Sixty students participated in this large-scale experiment, confirming that the addition of audio increases presence and 3d-depth perception with an effect size of $r=0.78$. Last but not least, the meta-analysis by Bailenson et al. (2001) highlights the importance of direct gaze and personal space for realism. An avatar looking at an audience member will instill a higher degree of presence. Specifically female audience members reacted to direct gaze with a higher degree of social presence. The study takes social factors of realism into account, explaining how social interaction affects users' perception of presence.

All six studies presented in the formal analysis were tabulated according to Cochrane-style practice: for publication year, sample size, sample constellation mean of age and gender, standard deviation of evaluation and control group as well as P-value and effect size. Effect sizes followed models presented by Cochrane Review (Cochrane.org), Rosenthal (1984), and Nature.com (2013). David Wilson's "Practical Meta-Analysis" (Wilson 1999) provided methodological secondary literature. The effect size variable r (Pearson's r) substantively compares the impact of a variable on another – independent of measuring units. Where r was not reported, r can be calculated either from t-tests, or directly from standard deviation and means. Effect size cannot be easily calculated from ANOVA or F-test analysis without access to data on standard deviation or means. In these cases, the study was excluded from formal analysis. All r -values were averaged by the weighted inverse variance calculated from sample sizes, control groups and standard error of a study. Tabulated results were compared for heterogeneity and overall z -value - presented in the appendix.

Primary Outcomes

A sample of 256 participants across six studies indicates a medium effect of realism on presence. The effect size weighed by participants amounted to $r=0.49$. This weighed mean effect size approximates a large power by Cohen's effect size convention (1988). Weighed by inverse variance weight (w), the standard error of the mean effect size $SE = 0.08$, the mean effect size ES for across all six studies decreases to 0.30. This is regarded as medium effect of the independent variable realism on the dependent variable of presence perception. This result indicates a significant effect of realism on presence. In order to validate results, we need to establish the correlating Z-score. Furthermore we need to establish the Q-value for homogeneity, so to ascertain statistic significance. Weighted standardized mean difference equals 156.93. The weighted means odds-ratio amounts to Mean $ES = 0.46$. The Z-score for this meta-analysis is calculated by dividing the weighted mean effect size of all studies by the standard error of the mean effect size. The resulting z-value for the mean effect size equals 5.76 with a lower confidence interval at 0.3 and an upper at 95%.

Heterogeneity is a key concept of meta-analysis and defined as differences in methodology or study populations. Heterogeneity is prevalent if the null hypothesis of homogeneity cannot be rejected. Q , the value of homogeneity statistics (Viechtbauer 2010), is distributed as χ^2 , in this case with 5-degrees of freedom. Following the variance method for Odds Ratios (Lipsey & Wilson 1999), we can calculate Q , which equals 0.012. As this number is below the critical chi-square value of 16.92, the null hypothesis of homogeneity cannot be rejected. As variability doesn't point to a sampling error, this variation was likely due to heterogeneity.

Heterogeneity is measured either as Q or complimentary as I^2 . The advantage of I^2 is that Q -tests are corrected by degrees of freedom. Cochran's Q is usually calculated as weighted sum of squared differences between study effects and the combined effect across studies (Cochran.org) As Q has a relatively low power for small amount of studies, observational studies tend to demonstrate a propensity for heterogeneity of methodology and results (Sutton & Abrams 2000). As this meta-analysis draws from study results across a multitude of fields, heterogeneity doesn't come as a surprise. If heterogeneity is very strong, the power of the statistic result is insufficient. The z-value of 5.7 derived from formal data analysis results in a probability value of 0.99, which is within the threshold of significance. Despite substantively meaningful results, the heterogeneity of different experimental designs points to diverging test parameters, differences in presence conceptualisations, and the heterogeneity of input variables. Sources of inconsistencies can arise from discrepancies in conceptualisations of presence in different studies, the difference in measurements of realism (objective body metrics or subjective measures) or different standards (SUS, W&S, recollection tests, different underlying metrics and

measurement units). As research instrument, meta-analysis is often criticized for heterogeneity of evaluated studies – the idea of comparing oranges with apples. Too often numerical evaluation results conceal construct differences in individual study designs. Realism, as a conceptual construct is extremely complex, possibly amounting to more than the sum of its parts. The concept itself cannot be easily generalized without becoming ambiguous and generic in its statistical validity. The results of the formal analysis show that realism is linked to presence with a medium power, yet these results are not statistically significant due to the heterogeneity of the research designs.

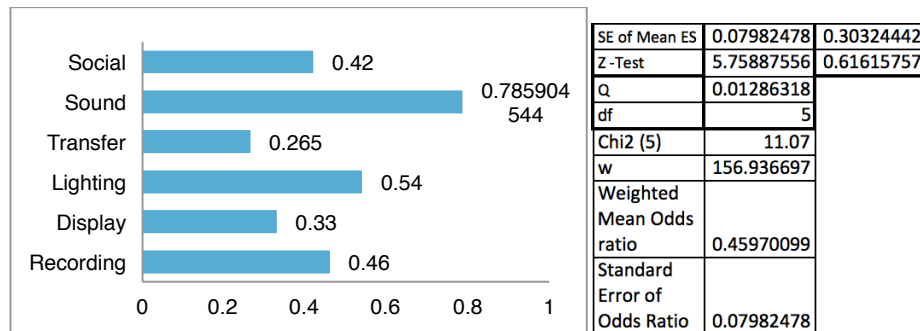


Fig. 46 Realism Factors Comparison

Table 7: Meta-analysis Study Result Table

Secondary Outcomes

The formal part of this meta-analysis yields explicit, yet inconclusive results – a paradoxon arising from heterogeneity of underlying research designs. Consistently, five out of six studies demonstrated a significant effect of realism on presence. All studies indicate at least some degree of power. Significance in results was diminished by heterogeneity of measured constructs. This should not distract from key conclusions that analysis of these studies provides: Statistical evidence for a link between realism and presence exists, and this evidence stretches across a number of related, yet very distinctive fields: Recording parameters, display parameters, image transfer (framerate), lighting, social factors such as direct gaze and sound. Intriguingly, sound plays a very significant part in the creation not only of presence, but realism in user perception.

A large body of studies is concerned with the role of realism plays in virtual environments (Slater, Khanna et al. 2009, Meijer et al 2009), This research contributes to development of methods to authenticate simulacra, whether this is in gaming, in cinema, in virtual environments or Pepper's ghost (Steuer 1992, Schubert, Regenbrecht, Friedmann 2000). Not a single strategy, only a multitude of propositions prevails. The informal, descriptive part of the meta-analysis takes a closer look at realism, discussing its relevance in the light of the STM model, as well as the specific context of media art on Pepper's ghost displays.

	Index	Independent Variable	Authors	Study		Age mean	SampleSize	Female	Male	Mean	SD	Mean'	SD'	p	r	N1	N2	Reliability	SE	w	ES	ES*w	
Recording	3.3	Center of projection	Yun Ling, Harold Nefs et al.	The Effect of Perspective on Presence and Space Perception	2013	26.15	24	8	16	38	12	37.5	11	0	0.46	12	12	$\alpha=0.92-0.98$	0.08	156.25	0.46	71.875	
Display	10	3D Spatial cues	Styliani Syliou et al.	Presence-Centered Assessment of Virtual Museums' Technologies	2008	28	46																
Lighting	15	Lighting Design	Katerina Mania & Andrew Robinson:	The Effect of Quality of Rendering on User Lighting Impressions and Presence in Virtual Environments.	2004		36	6	30	2.66		2.77		0.05	0.54	12	12		2.57811301	0.15045135	0.54	0.08124373	
Transfer	22	Frame Rate	Meehan, M.; Insko, B. et al.	Physiological Measures of Presence in Stressful Virtual Environments.	2002	22.3	33	8	25	3.2		6.3		0.01	0.265	33	33		2.96742415	0.11356402	0.265	0.03009446	
Sound	25	Audio Presence	Elizabeth T. Davis, Kevin Scott, Jarrell Pair, Larry F. Hodges, and James Oliverio	Mutual gaze and personal space in virtual environments.	1999		60			3.425	0.14	3	0.2	0.03	0.785590454	60	60		6.86932355	0.02119201	0.785590454	0.01665489	
Social	31.2	Direct Gaze	Equilibrium		2001	24.5	50	26	24	-13.3	18.6	2.5	16	0.03	0.42	40	10	$\alpha=.83$	3.2596012	0.09411765	0.42	0.03952941	
					Total						249	48	95									156.936697	2.80090454
		Average			2004.5	25.2375	37	17	20	6.589	8.28	9.295	7.4	0.11	0.46681742	27.7	22.7				0.49220591		
		SD			8.48528137	1.1667262	18.3848	12.728	5.6569													0.45970099	

Table 8:
Meta-analysis Study Result

9.8 Aura – Informal Meta-Analysis of Realism Factors

The STM framework differentiates between seven different categories of realism components. This taxative categorisation is the result of the literature review presented in previous chapters and by no means exhaustive. The framework helps to differentiate between key factors from image production to the final transferred image. The existing breadth and heterogeneity of studies makes their attribution to one or the other category rather arbitrary, yet a systematic presentation and analysis facilitates the maintenance of an overview, and guarantees a degree of structure in the discussion of realism factors, specifically in the context of Pepper's ghost. Selection criteria followed the same stringent selection criteria applied to the statistic analysis.

The informal, systematic analysis is segmented into seven different fields relating to the STM framework in the context of my creative practice. This allows for a sense of consistency, and follows a typical Pepper's ghost content production pipeline from recording, to lighting, from image transfer, to display – all the way to image perception (social factors and suspense of disbelief). All studies form part of the master catalogue presented in tabulated form in the appendix. Design of a virtual reality environment starts with the consideration of the final result, the end product. Without being able to anticipate the point of view, the perception environment, the playback format, the final impact, not a single creative or technical decision can be made. This consideration becomes even more relevant when attempting to maximize presence experiences for a virtual environment such as Pepper's ghost. The effectiveness of realism depends largely on the degree of anticipation of the display method. Image recording parameters assign adequate values to the image creation, whether this concerns technical specifications, decisions on perspective, colour or scale. Recording parameters allow for a pre-emptive optimization in the production process: Dialling in relevant parameters from the outset, assures the impact of the mediated experience. Correspondingly, recording parameters have received a lot of attention in academic discourse: Not only in the fields of psychology, media studies, but moreover in motion graphics and animation, recording parameters have been subject of academic debate from a perceptual and technical point of view. All studies presented in the descriptive summary of the master catalogue met the criteria of selection, not all were included in the formal, statistical part of the meta-analysis – be it due to poor construct validity (small sample size) or missing data on mean and standard deviation. This descriptive, informal meta-analysis provides an overview of existing research relevant to the field, with a specific focus on applications in the context of Pepper's ghost. Literature exegesis is related directly to the Standard Model. Examples of media art practice on Pepper's ghost highlight applications of realism-induced presence within the context of holographic projection art.

9.9 Recording factors for Pepper's ghost display

In the creation of photorealistic imagery for Pepper's ghost displays, recording parameters play a fundamental role. Not only are they subject to financial and technical consideration on quality versus cost, but the choice on recording parameters always depends on the context of the display environment, the addressees and their anticipated perceptive realities. Holographic projection is unique in providing at once a plethora of possibilities and a wealth of limitations: Realism, as a key component of presence experiences, plays an axiomatic role in achieving the intended effect. Contrary to other media, the question of user perception is posed right at the beginning of the production process:

The human visual system (HVS) has been outlined mathematically in perception research: Specifically, Daly's Visible Difference Predictor (VDP), Manos and Sakrison (1974) among others, developed models to measure and predict the subjective perception of the human visual system. Rushmeier (1995), at the National Institute of Standards and Technology, further tested the models with applications in image rendering, resulting in promising new avenues for image analysis. Yet, holographic projection demands a new form of realism: In its quest to confuse audiences, to suspend disbelief, holographic projection constantly pushes the boundaries of audience expectation. The demarche in creating the perfect anthropomorphic, realistic representation starts with the correct recording standards – ideally parameters in anticipation of users' ultimate panoply. However generic we want to ask the question, certain universal attributes can be singled out for recording standards.

The holographic screen acts like a window into a different world: like glass, it is invisible in itself, like a window holographic projection enables to glance into another reality: In 1435, Leon Battista Alberti, promulgator of the Renaissance, wrote his famous treatise on perspective – “De Pictura” – presenting the first account on how to transform a 3-dimensional image onto a 2-dimensional canvas (Friedberg 2006). Alberti understood the painting as an open window “through which I see what I want to paint”. The Alberti window, or one-point perspective, turned into a systematic method, transforming 3-dimensional space into a 2-dimensional representation. Holographic projection reverse-engineers the Alberti's window: 2-dimensional content is presented in a 3-dimensional world: The screen becomes a canvas, the world a projection: The perspective of the user, the one point perspective, is anticipated in the production process, to assure the conflation of virtual space with the real-world environment – to create the perfect illusion that turns the screen into a window of possibilities.

Perspective is key in the creation of a convincing holographic illusion: The one-point perspective, correlates all points perpendicular to the image plane, starting from the viewer's vanishing point, the point of infinity. This conflation of perspectives into an ideal viewpoint is at the basis of holographic design. The user's perspective onto the holographic plane -an accurate approximation of individual's and collective's point of view - builds the foundation for a holographic Alberti window that permits the suspension of disbelief. The human visual system, its limitations and sensitivities are at the heart of this anticipation: Academic research helps to contextualize and explain some of these parameters:

Alberti's window results in a foreshortening of lines to convey perspective. The illusion of depth and 3D presents one of the most fundamental principles in holographic creation: To turn a 2-dimensional recording into a 3-dimensional image requires a multitude of tricks of the trade, an effectual understanding of the human visual apparatus' operative proficiency. Research proved measurable discrepancies between perceived and actual distances within pictorial and physical space - using standard optics. This incapacity of the human visual system to judge distances effectively plays to the advantage of the holographic production process: The visual perception system is better equipped to judge distances at a close distance rather than on a far plane. The experiment presented by Caspar Erkelens (2015) has a specific relevance to Pepper's ghost presentations: Depth far plane and z-space perception struggles to distinguish distances over six meter accurately . Distances on a virtual image are consistently anticipated to be closer than in reality. Active obfuscation of distance perception is a key factor in the creation of Pepper's ghost illusions. Distance perception increases with eye height, ergo seated audiences are easier tricked into artificially enhanced depth perception. Ling, Neffs and Brinckan (2013) discussed the effect of vantage points and field of view (FOV) on presence. Comparing life-sized displays, distances of virtual images, and the center of projection with the respective vantage point, they found intrinsic relations between the audience position and perspective onto the virtual environment. The position of the audience in respect to the chosen framing, angle and virtual camera position significantly influences the effect of presence. Interestingly a higher degree of presence is observed for elongated virtual spaces while veridicality in perspective tends to be ignored.

Ling et al. underscore the need to assure perceptive and perspective integrity in Pepper's ghost content production. The study shows that a wider field of view results in a larger degree of presence and that viewers along the center axis of projection will have a higher perceived degree of presence than users with a more acute angle positioned to the left or the right from the center of axis. For Pepper's ghost displays this result indicates that a larger screen size will increase presence perceptions. Shifting the vantage point towards the center of projection seems to enhance presence, whereas shifting it away reduces

presence. Audiences closer to the projection plane profit from perspective advantages over subjects further removed at a distance from the vantage point. The authors note a discrepancy between actual and perceived vantage point: The audience assumes the ideal vantage point to be closer than actually is the case, a proposition that is consistent with Erkelens research. The authors furthermore conclude that a sense of presence can be predicted through the layout of the virtual room. This reaffirms that spatial layout and active design processes largely contribute the effectivity of a virtual environment. The center of projection, or indeed the camera angle of the created image thus preconditions the impact of the illusion. Another important conclusion from the study is that artificially elongated perspectives yield larger degrees of presence. The importance of perspective for impressions of immersive qualities has been highlighted by a number of studies including Hoshi and Waterworth (2009), Jeong (2008) and Kallinen et al. (2007). In the context of Pepper's ghost, key findings relating to recording parameters point to the relevance of perspective. Merging the perspective of the audience with the recording environment, thereby rendering the user's viewpoint identical with the so-called Alberti window, the ideal point of view yields minimal perspective distortion.

A study by Loschky, McConkie et al. (2001) points into the same direction: Testing methods to compress image bandwidth through filtering, Their research team created a method that takes retinal eccentricity into account: Their display method produces high resolution imagery that corrects for eye movement parameters and is only perceivable in high resolution at the center of the optical system. Visual resolution is at its best at the center of the fovea. Equally, the best visual acuity has a very small angle of only 2 degrees (Yang et al. 2002). Within the context of Pepper's ghost, these findings suggest, that imagery positioned at the center of the display apparatus will be perceived better than imagery on the periphery of the field of view. Perspective and its importance for presence has been subject of a multitude of studies. Research by Bracken & Botta (2002), Hendrix and Barfield (1996), Ijsselstein et al (2001), Prothero and Hoffman (1995), Shim and Kim (2003) and Snow and Williges (1998) analysed the importance of the field of view for user perception of virtual environments. The field of view is not only of relevance in respect to display size, but also with regards to recording and animation standards.

Watson, Ahumada and Farrell's study "The Window of Visibility" published by the NASA is a technical-mathematical analysis of framerates, refresh rate and shutter speed (Watson, Ahumada & Farrell 1983). Based on an experimental self-report, this thorough investigation into the perception of spatio-temporal motion provides technical and mathematical insight into recording parameters. Presenting formulas for contrast distribution of stroboscopic motion, as well as the limits of human perception of spatial and temporal frequencies, provides a technical synopsis of recording parameters. The

resulting formula was tested by a two-interval, forced choice experiment. 25 trials compared different sampled stimuli against a smooth sample frequency of 1920 hertz (hz). A lower limit, or intercept for smooth motion was measured at 30hz, a result that was firmed up in a secondary experiment. A second focus of this study is the development of a formula to describe lower limits of strobing in the recordings process for frame-rates and shutter speed. The weakness of the study design lies in its insufficient objectivity, questionable repeatability of presented experiments and the subjective nature of results. Accordingly, the study has not been included in the formal meta-analysis review. In the context of Pepper's ghost, the avoidance of described motion artefacts (strobing, smooth motion) is extremely relevant. Motion blur or strobing are perceived as archenemies of realism on a holographic projection display.

A study by Johnson, Dale, Avidan, and Pfister (2010) presented means to improve realism of CG imagery by comparing large image repositories: Across three separate experiments, the authors build on image comparisons and questionnaires, evaluating key factors of image fidelity such as image size and frequency of information: Larger images increase users' ability to distinguish fake computer-generated images from real representations, as information size increases. Another test on the same sample compared factors such as image tonality (hue, saturation) and texture. This study showed that although colour and tone improve judgement of realism, key factors for accurate user judgements are texture and information frequency. Higher spatial frequency results in a more plausible, believable and realistic picture. Within the context of Pepper's ghost, this means providing visual cues that assure a dense, and high-spatial informative input. Plain surfaces and textures with less information will result in a diminished degree of realism. This landmark study -supported by Harvard, Adobe Systems and MIT- confirms that accurate colour, and tone representation is contributive to perceptions of realism, but to a lesser degree than visual density and spatial frequency.

Paul Rademacher's dissertation (Rademacher 2002) can be regarded as key research paper scrutinizing realism factors across different dimensions: Following a thorough and rigorous experimental research design with control groups, a clear methodology guaranteeing validity, objectivity and reliability of the experiment, results account for key findings in the field. Using linear regression, Rademacher assesses realism across five properties of realism on 18 subjects. Out of five criteria - surface smoothness, number of objects, object shapes, number of light sources- Rademacher only proved a direct effect on realism for two factors: Surface smoothness and shadow smoothness both affect the perception of realism with statistic significance. Surprisingly, number of light sources, object shapes or number of objects showed no significant statistic relevance. Rademacher's study confirms the importance of texture exactitude and complexity for

image fidelity. Conversely, the number of objects depicted in a virtual image seems of little importance to user's perception of realism.

A study by the Greek research team around Styliani Sylaiou (Sylaiou et al. 2008) investigated realism in the context of virtual museums. The study with a sample of 46 participants not only points to the importance of interaction for the experience of presence, but also reflects on the factor of time and latency for the perception of realism. The importance of timing, delay and lag for the successful perception of presence cannot be underestimated. A number of studies have pointed to the importance of time for presence experience - specifically frame rate (Mastoropoulou & Chalmers 2004), update rate (Chen & Throp 2007), delay (Meehan et al. 2002), and lag (Bryson 1993). In the context of Pepper's ghost facilitated telepresence, where any delay can result in disjointed or interrupted communication flow, the importance of time, and minimal delay becomes even more important. Reviewing over 56 studies, Chen and Throp attested a minimal threshold of 15hz for speech recognition and perceptual tasks. Out of all reviewed studies, only two (Watson et al. 1998, Lion 1993) pointed to a higher threshold.

Kira Zhigalina's "The Ephemereal Lightness of Being" made lag a key feature of a real-time dance performance (Ki-Ra 2010). Creating a kinetic sculpture of ripples of time, colour echoed around a live performer as a visual imprint of her movement. Controlled via a self-triggered LED dress, the artist played with lag, framerates, shutter speed and the impossibility of a camera to display its own image. Creating an ever-repeating feedback loop of colour and motion, space, time and movement were interlinked as a holographic projection piece. Gaëlle Berton's "Antiform" (2014) suspends gravity and time alike as an arial performer flies through the air, reflecting and emitting light, changing the speed of performance, accelerating and circumventing time while radiating light through movement.

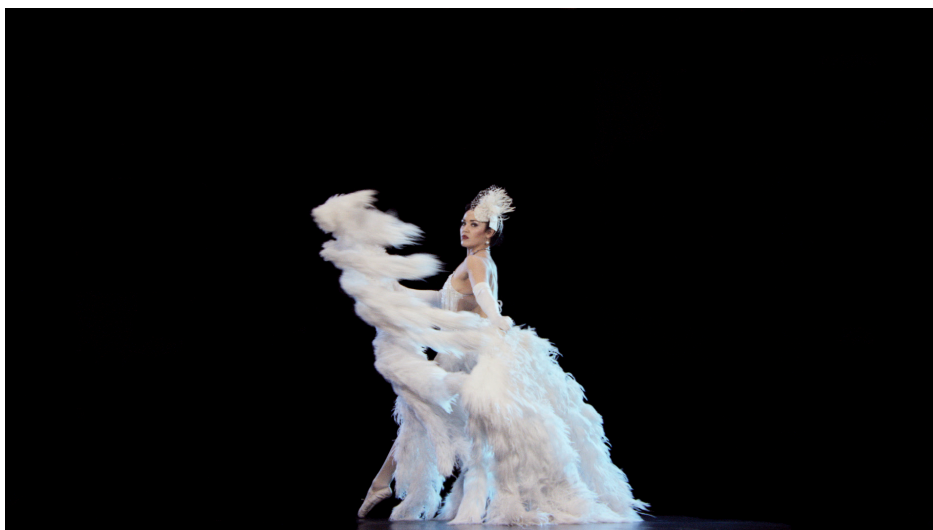


Figure 47: Smoke and Mirrors: The Swan – Laura Jean Healey

9.10. Lighting as the holographic paint, brush and canvas

Holographic image displays conjure the art of illusion through sculptural qualities of light: Light acts as paint, the solution, the canvas for holograms. Essentially, holographic projection is the manifestation of light as kinetic sculpture, perceived as 3-dimensional form within a spatial environment. Lighting not only acts as the mediator, it also turns the stage environment into a spatial canvas onto which we project. Without lighting the stage, holographic illusions lose their multi-dimensional impact. Without lighting at recording, holograms become transparent or even invisible. Lighting acts as virtual paint, a stencil, to veil and to unveil the holographic form.

The function and pivotal role of lighting in creating realism in animation has been subject of ongoing academic debate (Mania & Robinson 2004). Bertin (1983) discussed the complexity of light (shadows, interreflections, surface attributes). The role of specular and diffuse lighting in realism were first analysed by Cook and Torrance (1982). Famously, Blinn (1977) developed an algorithm to describe the composition of diffuse highlights mathematically. Watt and Watt proposed more complex anisotropic light algorithms (1992). Hanrahan and Krueger developed computational representations of unknown complexity with the Montecarlo method (Hanrahan & Krueger 1992). Montecarlo renderings were further improved with the development of raytracing (Whitted 1980) and radiosity (Goral 1984). Complexity of algorithmic shaders and computational power constantly increases. A variety of algorithmic methods assure that rendering methods reflect the limitations of the human visual system.

At Imperial College London, Mohamed Elhelw et al. investigated the role of light in creating visual realism through gaze analysis (Elhelw 2008). Their extensive experimental research makes use of saccades, rapid eye-movements scanning each and every visual scene, to correlate subjective questionnaire data with quantitative measures. Sixteen observers were exposed to a series of both computer graphics (CG) and non-CG images to assess degree of realism. Using a forced choice task, eye-tracking data was recorded for assessment and correlated with questionnaire results. Two experiments evaluated images of a bronchoscopy – one realistic, one virtual. Observing user's focus on a specific image location suggests that certain areas are more relevant for decision making processes. The second experiment proved statistically that detailed specular highlights increase viewers' sense of realism. The use of highlights, as opposed to flat, diffuse lighting, is thus contributive to the perception of realism. This causality is relevant in the context of Pepper's ghost: Specular highlights are frequently employed to direct viewers' attention.

Presence research holds valuable lessons for the production of Pepper's ghost pieces, for recording as well as display standards. Research by Eugene McSorley (2010) suggests that inhibition of distractors in the visual field improves accuracy of the saccadic eyemovement. In the context of Pepper's ghost, this provides further evidence for the relevance of lighting in conjuring on-stage realism. Lighting not only engenders important depth cues for the audience, but directs visual focus on the holographic projection plane. McSorley's relatively small experiment measured eye movement as biometric indicator. Calculating visual attention with and without distractors demonstrated that accuracy markedly improved as saccade latency increased. McSorley points out that visual accuracy can be augmented until a certain threshold of 200ms is reached. Distraction is seen as a magician's most important trick: The presence of a distractor utilizes an involuntary side effect of the human visual system. In the context of Pepper's ghost, this proves that a stage equipped with distracting elements such as lighting or set design can actively contribute to the illusion.

Rademacher's findings prove that the number of light sources employed in a given scene is irrelevant to image realism (Rademacher 2002). In the context of Pepper's ghost, adequate balance of lighting distribution contributes dramatically to realism. Flynn (1975) discussed the role of lighting as environmental component of realism. Promoting visual quality of a room, he considers lighting as element of design rather than mere functionality. Mania and Robinson's study on the effect of quality rendering on user impressions (Mania & Robinson 2004) successfully demonstrates that in high quality, realistic lighting conditions of a virtual image, presence scores increase with a range of lighting attributes: A statistically significant correlation of presence and lighting was evaluated for high quality radiosity renderings with a power of $r=0.54$: Ratings for "comfort", warmth, spaciousness and relaxation i.e. attributes associated with purposeful lighting design, increased reports of presence.

Light artists such as the studio Cinimod, or designer Liz Berry reinvented the way that light contributes to holographic image creation. Not just mere facilitator, but as quintessential element of spectacle, light acts as "paint", texture and substance of holographic image projection. The specific role of contrast in lighting, spread, diffusion etc. will need to be subject of future research. The artist Dominic Faraway presented his landmark piece "Maggot Brain" at Kinetica ArtFair 2012. The piece makes exceptional use of highlights and reflections to create a humanoid sculpture that slowly disintegrates. The piece presents an incredible degree of stage realism: Highlights, speculars, and reflections cause the eye to perceive a mercury-like sculpture that is at once inanimate and animated.



Figure 48: Dominic Faraway - Maggot Brain 2012

9.11 Image quality and image fidelity

A large number of studies discuss questions of image display, quality and size as a key factor for realism. In presence research, image analysis, computer graphics and psychology, questions on effect of image quality continue to remain of utmost relevance. Image resolution can be seen as key factor for image quality. Research by Shaojing Fan et al. (2014) at the University of Singapore suggests that resolution presents a core element of realism. On the other hand, clipping of an image's composition limits realism: The effect of resolution on presence seems to be cumulatively expanding, if depicted imagery is not revealing all of the facial features. Fan and his team compared key-factors of realism in an experimental research design. Factors such as colour, mis-alignment or resolution were tested across a total of 720 images, probed by 51 students. Misalignment of an image composition proved to have a smaller effect on realism than expected.

The second study presented by Fan comprised 670 students across a total of thirty images. Testing "holistic" versus "piece-meal" representation of facial features, the authors investigated if the depiction of a complete form i.e. of facial features has any measurable effect on presence. Their findings proof the importance of holistic image features in facial recognition, specifically for imagery with lower resolution. Imagery depicting all of the facial features, with no occlusion or partial clipping, revealed a larger degree of presence. In the context of Pepper's ghost, a holistic image is a *conditio sine qua non*. Images exhibiting only partial representation of the human body are perceived as irritating, risking a drift into the uncanny valley (Mori 1970). The study also highlights the importance of gaze for viewer perception, realism assessment and judgement.

McMahan et al. (2012) investigated the effect of display fidelity, field of view and interaction on user's sense of presence, their performance and their level of engagement. Users' reaction was weighted through questionnaires and performance data. McMahan compared two display modes: A fully immersive 360-degree CAVE environment and a standard display. Both were evaluated across 24 different dimensions. Kinetic interaction proved to result in a significant effect on user responses, engagements levels and performances – as the Transmission case study suggested. In the context of Pepper's ghost, this study further bolsters the importance of field of view for perceived presence. Larger setups will inherently result in a higher degree of realism, a higher degree of user engagement due to a larger field of view. Interestingly, response times showed to be slower on a larger, more realistic display. Further evidence for the relevance of field of view and display size for realism is discussed in research by Ling et al. (2013). Their factorial repeated measures ANOVA showed strong statistic evidence for a correlation between display size, life-size representation and presence experience. Desney S. Tan et al. (2003) further demonstrated the effect of display size on presence and user performance. Unsurprisingly, life-sized, proportionate representation is one of the key factors in holographic representations. Deviations from actual body-metrics tend to be perceived as a drift into the uncanny valley.

At the Samsung Advanced Institute of Technology, Hyunjung Shim & Seungkyu Lee (2012) developed a technique to enhance realism through the use of contrast and colour. Modulation of chroma levels in certain areas of the image colour spectrum seemed to enhance realism significantly. In a binominal quantitative test with over 600 user inputs, indicates a strong link between used colour spectrum, contrasts and perception of realism. Pointing in the same direction, a study by Laurence Meylan, Scott Daly and Sabine Suesstrunk (2006) assumes that limiting the colour spectrum in combination with use of highlights and contrasts improves realism. These findings support evidence by Elhelw et al. (2008) on the importance of speculars for realism perception. Specifically on Pepper's ghost displays, the creation, preservation and mediation of realistic imagery is influenced by accuracy in human skin tone depiction, vibrancy and a balanced skin tone. Meehan, Insko et al. (2002) measured the effect of framerate of displays on human perception. Testing different framerates in conjunction with heart rate measures, skin conductivity, presence questionnaires, Meehan & Insko's research combines objective with subjective research methods. A user experiment measured with statistic significance ($P < 0.05$) that higher framerate results in a higher degree of perceived presence. This is specifically noticeable in changes from 15fps to 20fps and 15fps to 30fps. In the world of Pepper's ghost content production, the importance of framerate and the nuances between 25fps and 30fps are well documented (compare: expert interviews on Pepper's ghost in this chapter).

In practice, the essential nature of display parameters such as size, resolution, quality, is undisputed. In the context of Pepper's ghost, the importance of technology factors such as luminance or colour-spectrum requires further experimental research. Flexibility of adjustments, quality preservation over a long life-span and differences between high-brightness LEDs and high-resolution projection are subject of corporate and industrial research and development. DLP (Digital Light Processing) projectors strive to meet demands of high dynamic range, high resolution and high framerate. Intricacies of quality control are met through projector support, image-blending for multiple projectors, colour balance, correct brightness levels. Such know-how and technical expertise remains the domain of skilled technical engineers with experience in the field of Pepper's ghost projection. As much as technical know-how dictates the outcome of successful holographic projection, creative use of Pepper's ghost technology can be cultivated through arduousness and artistic perfectionism.

A number of artists explicitly played with ideas of image quality and image degradation: Laura Jean Healey's "Smoke & Mirrors: The Magician" (2009) was colour corrected to look like it originated in a different era. Playing with contrast and extreme levels of dynamic range, Sapolab, Shaun Prickimage, Dan Strutt and the dancer/choreographer Joe Garcia performed the real-time, motion-controlled interface "Metaman" (2012). Metaman reflected on a sorcerer's apprentice narrative, a hyper-realistic simulacrum: As a tail on anthropomorphic creationism, "Metaman" was displayed in high-dynamic range of metallic real-time shaders. The artist Omboy's piece "Terri Blue" (2008), created with the electronic avant-garde musician Coldcut, openly plays with the ideas of tease and disguise through image distortion. Cecil B. Evans explores virtual identities that are never really capable to leave the space between realism and virtuality, inhibited by holograms.

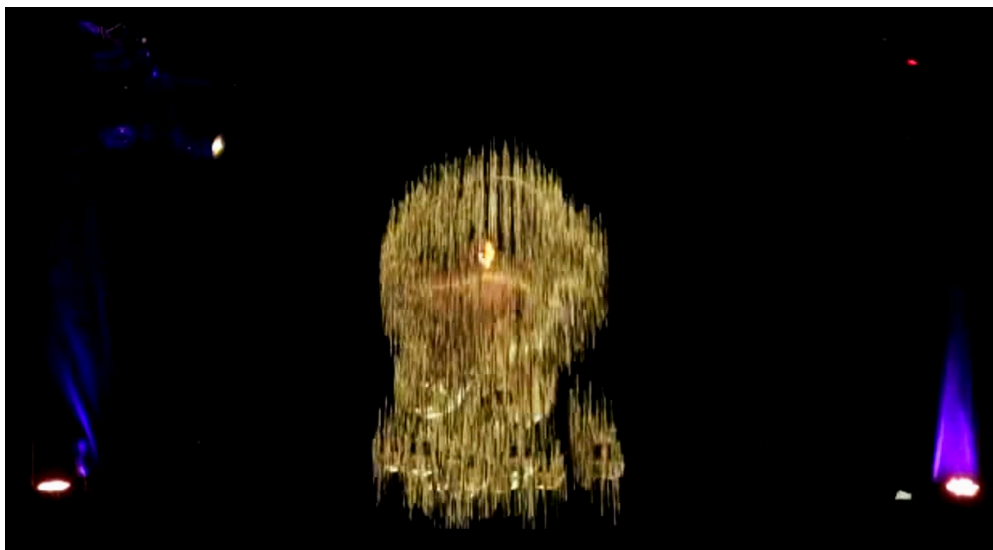


Figure 49: The Creation of Metaman – Sapolab et al. 2012

9.12 The role of sound in realism

A wide range of studies supports the idea that sound plays an integral, fundamental role in the generation of presence. As portrayed in the piece KIMA, a number of studies link sound to presence, and not at least immersion (Jeung et al. 2009, Larson et al. 2007, Dinh et al. 1999). Yet only few discuss the link between sound and realism. Elizabeth T. Davis, Kevin Scott, Jarrell Pair, Larry F. Hodges's research, provides very strong evidence for the influence of sound on presence and even depth perception within a virtual environment (Davis et al. 1999). James Oliverio (1999) investigated sound and realism by examining the same virtual environment in multiple trials: An experiment with 60 users compared a soundscape with low fidelity to one with high fidelity, and ultimately against a control group without any sound input. The study combined a mix of methods - recall tests, forced choice experiments and presence questionnaires. Results demonstrate a strong correlation between sound and presence. Furthermore, the study shows that ambient sound can enhance 3D-depth, perceived realism, spatial and volumetric perception – a condition described by Storms (1998) as auditory-visual, cross-modal perception phenomena.

Storms experimental research, conducted with 108 subjects over three experiments, indicates that realism in virtual environments is directly related to both auditory and visual fidelity. In the tradition of Gestalttheorists, Storms discriminates between “similarity, proximity, fixation and object interdependence” as factors of sound fidelity. The so-called ventriloquism effect, describes the dominance of the visual sense over auditory effects: The ventriloquism effect (Howard & Templeton 1966, Pick et al. 1969) occurs for instance when we watch a ventriloquist perform: Despite better knowledge that the voice source originates from a ventriloquist, spoken words are attributed to the puppet. This effect has a direct application in Pepper's ghost display, where sound hardly ever originates on the stage itself, but is mostly distributed via speakers due to the sound buffering characteristic of glass and or foil. Speakers are mostly positioned in front of the stage or artificially amplified. Spatial fidelity tends to be underdeveloped and an afterthought in most productions. Ambient sound can result in the auditory-visual, cross-modal perception phenomenon, i.e. in enhanced 3D perception as described by Storms. Realism in sound, the absence of delay, and spatial sound representation, contribute to effective Pepper's ghost illusions. Vice versa, the absence of sound, or sound artefacts such as delay, lag or noise diminish the impact of realism of a Pepper's ghost illusion. This becomes relevant in the context of telepresence, where the need for adequate, prompt and accurate sound representation is even greater. Analema Group's KIMA is a perfect example of how sound facilitates and catalyses telepresence experience.

In presence research, the role attributed to surround sound remains ambiguous and contradictory. In “Here, there and everywhere” Lessiter and Freeman (2001) find no significant relationship between surround sound and presence, but a significant relationship between emittance of bass frequencies and presence, regardless of volume. The KIMA case study (Gingrich, Emets, Renaud, 2014) discussed the use of surround sound in presence experience in the context of my creative practice: The findings support the idea that surround sound emphasizes experience of presence.



Figure 50: KIMA at the Incloodu Deaf Arts Festival 2015

9.13 Social Cues – Behavioural factors

Social and behavioural cues play a much larger role in telepresence than one might assume. Nuances of interaction depend largely on user propensity to interact. A variety of factors directly influence an audience’s willingness to suspend disbelief. A Stanford-conducted meta-analysis on the impact of anthropomorphism in virtual environments confirms this assumption with statistic significance (Yee, Bailenson, Rickertsen 2007). Evaluating across 25 studies, the research team provides evidence that human representation on a visual display produces more positive social interactions, than without. More importantly, the more realistic a human looks, the more positive the social interaction is assessed. This rigorous meta-analysis provides a thorough overview of the effect of realism on social interaction.

A behavioural analysis by Garau, Slater et al. (2003) points into the same direction. 48 participants, selected in a randomized selection process, were monitored during an encounter between an avatar and a user within a virtual CAVE environment. The study suggests a strong relationship between quality of communication and behavioural realism

mediated by eye-gaze, which seems to be inferred directly onto the users. Gaze and eye-movement are crucial to realism perception, as studies by Shaojing Fan et al. (2014), and Brown & Perret (1993) seconded. Research by Michel et al. (2006) suggests that familiarity with the subject plays an important role in realism attribution. In the context of Pepper's ghost, use of human gaze is paramount. The "Mona Lisa Effect", the impression that a hologram looks directly at you anywhere in a room, wherever you are, has to be actively instilled. A subject maintaining eyecontact with the camera establishes a connection with the audience. Subjective feelings of presence increase with direct rapport, an actively educed, mutual perceptual agreement. Eyecontact establishes a connection, evokes social engagement: Alberti's one-point perspective applies to a multitude of points in the room: Like Leonardo's Mona Lisa, a hologram's gaze will follow you, wherever you go.

Familiarity, a key factor of realism, extends from virtual subjects to environment and context: Philips et al. (2012) discuss the relevance of familiarty of a spatial environment for presence experiences. Well-known environments ellicit a greater sense of presence. Philips' study involved more than 40 participants in an experiment, correlating EKG heart rate data and gait analysis (motion-tracking) with a post-survey test. Assessing users' reaction to three different virtual environments, real-world experiences acted as control group. Gait and survey data pointed towards a stronger sense of presence in an exact virtual replica of a real-world environment. During a follow-up experiment, 24 participants estimated physical distance inside the VR experience. The test showed a significant underestimation of distance, compared to an underestimation error of only 0.11% in the real world. The data supports an existing hypothesis that familiarity with the contextual environment plays a distinctive role in realism judgements. This study contradicts findings by Meehan et al. (2002) that multiple exposures to a virtual environment lead to a decrease in presence experience. Although familiarity with environment and context seem to contribute to presence, too much exposure proves counter-productive (Heeter, 1992). Distance and personal space are directly related to presence, as an experiment by Bailenson et al. (2001) established. In a study with 50 participants, the relationship between gaze, realism and personal space – i.e. distance to the subject was scrutinized. Within a fully immersive, virtual environment few participants "dared" to cross the space around an avatar. Only two users stepped "through" vial rtags and only did so when not directly being looked at. All participants demonstrated larger distance to avatars, than to similar shaped objects. Realism, gaze and even gender play a role in user behaviour. A significant effect was registered for women, who kept more of a personal space around an avatar.

In the context of Pepper's ghost, adequate distance to the subject matter is less a question of choice and more a question of necessity. Audience members are positioned a

minimum of three meters away from subject matter and projection plane in standard installations. Research by Bailenson et al. (2001) and Hayduk (1983) suggests that the footprint of “personal space” of audience members is slightly larger at the front than to the back. A degree of distance seems to be less of a hindrance to presence experiences due to the importance of personal space, specifically when gazed at by virtual subjects as in telepresence interactions. Direct engagement with the subject is a co-factor of presence. Research by Blom & Beckhaus (2013) reveals that interaction plays a key part in presence and realism perception. The effect of interaction on realism increases even further when coupled with tactile feedback. Cavazza’s research supports this argument, linking realism to the plausibility of causality (Cavazza et al. 2007). Direct contact, chains of cause and effect and personal dialogue are enhancing the perception of realism. In a study involving 53 subjects, Cavazza proved that realism is perceived higher, when users are presented with more plausibility between cause and consequence. Interestingly, research indicated the influence of time on causality: Michotte’s theory (1963) states that a reaction time of over 150 milliseconds or lower is perceived as coupled chain of events, evokes a sense of causality in users. Applied to the world of Pepper’s ghost, this suggests that a subject interacting in real-time in a telepresence setup, feels more realistic than a pre-record. Latency is, as has been shown, extremely important. The Transmission case study further bolsters this argument. Future research will be required to investigate the relation between gaze, dialogue, and social interaction across distance networks further.

Last but not least, a number of studies tried to prove the influence of personality traits on presence, without much success to date. Yet research successfully evaluated the effect of attention on presence. Users’ individual readiness to interact largely influences presence experiences (Slater et al. 2000, Bailenson 2001). Vice versa, inattentional blindness is the effect linking the relative inability to judge image quality when users are not focusing (Cater et al. 2002). In the context of Pepper’s ghost, art of distraction is used as one of the key tools to conjure an illusion. Diverting the audience’s attention through body movement (see: Zajonc 1980), through non-verbal gestures, directing gaze - are all tricks of trade of any illusionist. Artists have played with audience’s perception more or less overtly: In Birgitta Hosea’s “White Lines” (2009), the eyes of a subject keep the viewer transfixed in a spell – nothing else is visible. Line by line, the human form is revealed, while white colour draws the profile of the artist into space. Laura Jean Healey’s triumphant “The Siren” plays with the human gaze of her subject, an underwater siren, transfixing the viewer in a moment transcending both time and space. Shot in slowmotion underwater, the physics of time and gravity seem suspended. Viewers’ attention is caught by the gaze of an apparition - at once human and other-worldly. Merging art of the stage with art of the screen, subject matter and audience direct attention in equal parts. Healey’s master piece captures the dialectic of perception in its very essence.



Fig. 51: Laura Jean Healey's The Siren (2012)

9.14 The Uncanny Valley

The term “Uncanny Valley” was coined by Masahiro Mori in 1970 and has been subject of much academic debate ever since - in presence research and beyond (Canamero & Fredslund Minato, MacDorman et al. 2007, Senda & Shiba 2003, Seyama & Nagayama 2007). Mori hypothesized that the degree of realism of a robot or avatar follows a certain graph, in which pleasantness increases with realism up to a point. Believability dips into what he called the “Uncanny Valley”, before hitting a highpoint with perfect realism. Mori’s assumption builds on the observation that human resemblance of avatars is more accepted if representation is either largely approximated, or ipse factor identical to a human. Mere likeness, the idea of a simulacrum on the other hand can evoke feelings of uneasiness. An almost perfect replica can be perceived as eerie, unheimlich, uncanny.

Mori’s sentiment is echoed by researchers across different disciplines and is the subject of multiple publications (Canamero & Fredslund 2001, DiSalvo, Gemperle, Forlizzi & Kiesler, 2002, Fong, Nourbaksh & Dautenhahn, 2003). The uncanny valley has been well documented in all its facets: For instance, kids are known to react more to the uncanny valley than adults - in particular 3 to 5 year olds (Minato et al. 2007). In the field of presence research, two studies stand out: Wade Mitchell et al. (2011) and Seyama & Nagayama (2007) discussed the topic with respect to presence perception. The latter presented a catalogue of morphed imagery to a sample of 45 participants. Confronted with imagery on a sliding scale of realism from very realistic to almost doll like, users were judging a degree of pleasantness of human or humanoid representations. The

researchers found that a visual disjoint between human form and non-human facial features caused the biggest disconnection for the users. The lowest pleasantness score was registered either when eyes were perceived as 100% real or the head was 0% human. Vice versa, when the discrepancy between realism in facial features was largest, the uncanny valley increased the most.

Wade and colleagues observed the uncanny valley effect, when sound and image were not congruent or mismatching (Wade et al. 2011). Their study, conducted with 48 participants, yielded statistically relevant results, confirming the importance of sound and video synchronicity. Tinwell, Grimshaw and Williams (2011) argue for a reconsideration of the terminology, from an uncanny valley to an uncanny wall. In their eyes the hurdles in achieving complete realism are much steeper, the phenomenon more complex than originally envisaged by Mori. The phenomenon of realism remains fluid. As users become ever more accustomed to technical developments in animation and motion graphics, their expectations on what constitutes realism never ceases to decline. User anticipation of photo-realism seems to grow along with technical developments. Among other factors, Tinwell, Grimshaw and Williams cite realistic motion, and the absence of motion artefacts as key concern: This stance is echoed by MacDorman and Ishiguro (2006) who list jerkiness or rigidity in motion display, along with other motion factors (wobble, unintentionality, unnatural movements) as key artefacts of the uncanny valley.

Motion artefacts actively reduce the effect of realism in Pepper's ghost projection. Transparency issues can cause a drift into the uncanny valley, arising from missing light intensity. Dark areas, transparency of hair and silhouette can substantially reduce the effect of holographic projection and risk an uncanny valley effect. In the attempt to suspend disbelief, any discrepancy is registered. In the context of Pepper's ghost, the human eye is very unforgiving. An image appearing too static, too two-dimensional, loses its impact. No specific study relating the uncanny valley to Pepper's ghost illusions exists so far, but artists have played with this idea in many different ways.

Kinga Malisz, Marzena Rychlik and myself as Director of Photography created the piece Venus which plays with the ideas of translucency: A ghost-like semi-transparent figure - beautiful, yet eerie, appears on stage - its outlines clearly separated from the black drape behind it. Slowly, a human figure, identical to the silhouette of the ghost, manifests in the center of the projection. This secondary outline is at once different, yet fleetingly coincides with the ghost. Here, the uncanny valley is actively evoked: The human performer appears almost less alive, than the white, ghostly silhouette of the "Venus" illuminated by the bright light to assert its full presence.

Possibly even uncannier than these ghostly apparitions, is the development of a complete industry that closes the cycle between spirit photography, Dickens “Haunted Man” and the future of Pepper’s ghost. On 16th of April 2012, the late rapper Tupac Shakur was digitally resurrected using Pepper’s ghost technology. The possibility of bringing deceased artists back from the dead caused a surge in online activity and an unprecedented press hyper-activity: Within three months of its online release, the event reached over 20 million views on Youtube. A few months earlier, Frank Sinatra was brought back to stage for Simon Cowell’s 50th Birthday party. The footage was derived from original recordings of a performance for President Kennedy. In the same manner, Paul Arden, Saatchi and Saatchi’s late creative director and founder of the new directors showcase in Cannes was brought back to life for the Cannes Lions with the aid of Najma Bhatti and Vicky Godfrey’s studio. Recently Michael Jackson performed at the AMA American Music Awards and the singer Dusty Springfield appeared with her song “Spooky” in London’s West End, years after she had passed away. There is no better way to describe the feeling of uncanny valley, than to watch these performances. The intricacies of combining realistic motion, head movements, facial expressions, skin textures, lip movements with spectacular and yet convincing performances poses ever new challenges to push the technical boundaries of realism, to overcome the uncanny valley.



Fig. 52: Aura testing at MDH Holograms on Eyecandy Display – October 2015

9.15 Summary & Outlook

Persistent ambiguity in academic debate, on whether realism is conducive to presence experiences remains open, not so much because research results remain inconclusive, but because there might not be a single, possible answer: Realism, as a complex, multi-facetted phenomenon consists in more than just an audio-visual imitation of image fidelity: Invisible qualities such as sound, emotion, and not at least causality play a distinctive role in generation, creation and the design of realistic experiences of presence.

The Aura artefact points to an alternate reading of realism, one that does not require mimetic impulses, but that echoes and reflects reality on a subliminal, non-visual level. The complexity of the phenomenon itself is undisputed. Participant observation allows only for a limited degree of theory building. Aura, reflecting on the conceptual “Gordian knot” of realism, can only lead to conclusive results in triangulation with other research:

A thorough meta-analysis shows multiple causal relationships between a variety of realism factors. The STM framework groups these factors into different categories. A formal, statistic analysis shows a strong relationship between realism and presence, and measured by inverse variance weight a medium effect size of 0.3. However, heterogeneity of the studies makes a direct comparison impossible. Heterogeneity reduces the statistic significance of this Cochran-style meta-analysis beyond a meaningful threshold. Reduction of the concept to numeric, statistical denominators remains impossible. However, a narrative, informal analysis sheds new light on the phenomenon itself and its relevance in the context of Pepper’s ghost.

In the analysis of the master-catalogue, key components of realism and their relevance become apparent: Recording parameters such as image capture, colour values, framerate, shutter speed and perspective all contribute to realism design in the context of Pepper’s ghost. The role of lighting, as artistic craft, a sculptural tool and a property of perspective becomes apparent - not at least in the role as visual distractor (McSorley 2010). Image transfer standards, such as colour spectrum, framerate or image quality demonstrate direct impact on realism and by proxy, presence. Image quality – i.e. properties of display – such as image resolution, display size, colour spectrum and audience viewing angle affect perceptions of presence directly and indirectly. And last but not least, sound cues contribute to perceptions of presence, as the KIMA case study has effectively shown.

On a social level, a multitude of factors engender and facilitate presence: Interrante and Philips (2012) highlighted familiarity of the subject matter with the environment as a key factor for presence. The duration and frequency of exposure matters in Pepper’s ghost

setups and beyond as research by Meehan (2002) reaffirms. Finally, the uncanny valley, a human sensibility in the reception of anthropomorphism, has a specific relevance in the context of Pepper's ghost.

The Aura case study combines participant observation of an art piece, with a quantitative and qualitative meta-analysis and converges this data with an expert panel questionnaire. This quantitative data re-assesses meta-analytical input in the light of Pepper's ghost, confirming some of the observations and questioning others in the context of my creative practice. The research question, on the relationship between realism and presence has been addressed on multiple levels. The hypothesis of a direct relationship between presence and realism cannot be confirmed with statistic significance due to the heterogeneity of the phenomenon. Future research will need to dig deeper or try to find conceptual formulas that allow for intercomparison between different aspects of realism.

Presence, as we understand it, as a sense of being there, does not rely on realism alone, to engage, to augment reality – as all three case studies have shown. KIMA evoked a sense of presence by relying on sound as a mediator. Transmission used body movement as an activator for abstracted presence. Last but not least Aura used cognitive introspection to inculcate a sense of presence. The future of research in realism might need to be focused less on exploratory questions and more on explanatory exegesis of production, on practical concerns of designs, shading algorithms and thresholds of perception. As technology develops our ability to see through and past their potential increases, new challenges for creative and technical exploration open up. And a third way of creative development emerges: technical-artistic creativity in virtual experience design.

10. Conclusion

As the notion of new media changes, its directionality shifts from one to many (TV, newspapers), to a multi-nodal network (Flusser 1985, Deleuze & Guattari 1980), so do cinematic creation and theatrical performance. Not only are people no longer limited to receive, perceive and review, media turned from unilateral to bilateral to multilateral. Hybrid media forms are transcending all limitations. Holographic projection is no exception. The stage, previously the epitome of Aristotelian discourse, of apodictic cardinality, is slowly transformed not only into a canvas for animation and visual effects, but moreover into an interface for discourse – an Albertian frame across time and space: Telepresence allows for remote communication in real-time, connecting people increasingly without visual limitations to realism. As our ability to control these new forms of communication grows, presence experiences across distances increase. In a polycentric world, the possibility to transcend boundaries, in education, in art, in politics and in everyday life opens new routes for discourse, for collaborative creation and not at least for performance: Pepper's ghost is just one out of many possible forms of contemporary Alberti windows.

Across three case studies, I tried to illustrate three key aspects, not only of holographic projection, but its nonpareil that is presence in the context of my creative practice. A phenomenon that remains elusive, difficult to grasp, at once omnipresent, and intangible – this key aspect of virtuality has already become part of our everyday lives. Understanding its core components, here itemized as immersion, interactivity and realism might enable us to optimize its causatum, to create diverse, hitherto unfathomable experiences of otherworldliness with very practical applications - be it corporate, communicational or educational. Pepper's ghost has long been a black art, the magicians' best kept secret, yet it is not only the apparatus itself that fascinated scientists from Athanasius Kirchner to Dr. Pepper – it is the spectacle, the simulacrum, the conjuring that provides a forum for artists of the most diverse backgrounds to explore new avenues of creativity.

Analema Group, a collective founded by the artist Evgenia Emets, is specifically interested in the limits of our perception – this space between dimensions, the manifestation of invisible senses. Together with a team around the sound designer, artist, and my mentor Alain Renaud, we embarked on a journey to explore the limits of perception conceptually and creatively. KIMA, a tool for real-time music experience, emblematises this idea: Immersive music can act as a single activator of presence experiences in a remote location. As a real-time visual music instrument, a performance tool, an invitation to see, feel, create and experience music, KIMA in its initial form can be seen as a pars pro toto of how immersive experiences can eclipse temporal and spatial confinements that evoke presence.

KIMA's two-tiered case study results were conclusive, in answering exploratory questions on the role of immersive sound. Two interventions highlighted the role immersive sound can play in creating presence experiences across a distance. Quantitative analysis of presence questionnaire results were seconded by participant observation and a focus group conducted as part of the pilot. The hypothesis suggested a positive correlation between sound and presence: Comparing the UQO norm -an international evaluation norm- to results of KIMA's presence questionnaire showed that KIMA can be regarded as statistically comparable to other virtual environments, evoking a high degree of presence. In the context of my creative practice, the importance of immersive sound as component of presence has been confirmed.

The second case study, Transmission, is both, academic experiment and performative prototype. The ambition to contrast inner with outer experience, allows for a glimpse into how kinetic interactivity affects us. Whether on a holographic display or at a ballet, kinetic energy moves and affects us. With Transmission, this affection can be measured, visualized and sonified. For now a case study of data exploration, and an artistic prototype, the hope is to see Transmission grow – not only into a community of artists interested to engage with the universe that is the human brain, but moreover into a performance environment for introspective and exegetic locomotion. Transmission is a metaphore for interactivity, felt, sensed and actively performed.

This case study's hypothesis suggested a direct effect of physical interaction on user engagement (H1) and presence (H2). Whereas the first assumption was confirmed with statistical significance through EEG data evaluation, the experiment failed to prove a direct link between kinetic interaction and presence (H2). Further research into the subject matter is required, ideally with a technical overhaul of the environment.

The third case study explores the limits of perception, of observed realism, and of our senses. With Aura, I wanted to exemplify the realism of an inner landscape that is constantly in flux and motion, acts as a mirror to the soul. And yet, despite its arbitrarily ethereal characteristic, this integrity to human emotion, although invisible, Aura is just as real (or surreal) as any other representation. The case study also consists in a meta-analysis spanning over 70 studies, presenting 37 experimental designs in a narrative evaluation of realism factors. Applying this research to the context of Pepper's ghost exemplifies their relevance. Triangulated with expert reports, these observations become quantitatively meaningful. Yet the Aura-case study also shows the limits of statistics, the impossibility to break a very complex phenomenon down into discrete parts. Whereas the meta-analysis failed to prove any effect of realism on presence, the numeral analysis of expert interviews, as well as a formal meta-analysis and participant observation in the

context of my creative practice point to a strong interdependency between the two factors. The evaluation of the third case study study, would suggest the need for further research into the relationship between realism as a highly complex analytical, technical and conceptual construct.

The standard model presented as theoretical framework is an operational model, not a corset of terminologies: Triangulating three core components, all interrelated, all inter-subjective, one more perceptive and one more objectifiable, this research investigates their behavior, so to optimize performances. Artistically, I wanted to test limits of their conceptions in the context of my creative practice. The hypothesis of this study, to prove the relevance of co-factors of presence can only be supported with reservations, as units of analysis as well as its underlying constructs prove too complex to be captured with single exclusive disjunctions. As highly intricate constructs, all three co-factors influence each other, as much as the audiences' perception depends on their own propensity to engage.

Here, presence is conceptualized as an interactive remote communication experience with immersive qualities, resulting in the perception of realism. In the context of Pepper's ghost this phenomenon develops both physical and meta-physical qualities:

Over centuries Pepper's ghost has provided a platform for artists to push the boundaries of the feasible: In conjunction with the Laterna Magica at the Royal Institution 150 years ago, just before the world war during the time of the Alabaster, as an amuse bouche of cinematic performance and in this present day as a small renaissance of holographic projection which evolved around the Musion Academy.

Whether in the creation of entirely new immersive experiences such as the Madi Boyd's Spacetime (2012) and Lightharp (2010), whether as musical real-time music interactions such as New Opera Hero's Work Eat Sleep 2012 or Gaelle Berton's interactive Wii Control (2009) or Kimatica's real-time holographic sculptures "Simulacrum" or "Butoh" (2012) – Pepper's ghost continues to ask questions on the essence of perception. Who is in control of the gaze, the spectator or the artist? – questions elucidated by Laura Jean Healey's pieces. Whether realism is considered predominantly a visual experience as demonstrated by Madaleine Trigg (Sutre 2012), or an abstracted phenomenon as in Aura Aura (Analema Group 2015), the screen seems to have disappeared, not only behind the artist, but behind the medium itself. In Pepper's ghost, Lombard and Ditton's illusion of non-mediation has found a medium that is not only transparent, but that reflects back from the artist onto the audience, and from the audience onto the artists. Like a large scale "Looking Glass", Pepper's ghost offers a window into a different world, creating stage presence across distance, time, across media, and artistic genres: Film, the very

medium of cinema itself, is flipped upside down: And just as projection empowers audiences to perceive tiny images as larger than life screen experiences, the film that refracts Pepper's ghost grants access to the microcosm of artistic possibilities: Performance, photo-realistic communications, audio-visual real-time compositions, light sculptures, digital "resurrections", virtually augmented theatrical spectacles, a panoply of different art forms and possibilities. As a window of opportunities, this small renaissance of artistic creation around the Musion Academy and beyond hopefully opens the door for future generations of artistic ingenuity.



Fig. 26: KIMA: Wheel at the Camden Roundhouse as part of Ron Arad's The Curtain Call – performed during the Roundhouse's 50 year jubilee - August 2016. Photo by Paulo Ricca

11. Artist Interviews:

Interview with Evgenia Emets – Founder of Analema Group

For you as an artist, what do you understand as presence specifically in the context of KIMA?

How do you create that space where you can tangibly have the experience of the Other in the space. For me it has always been personally interested in the notion in making contact with the invisible realm and making the invisible realm very present in your life.

Artistically I was always interested in how this could work in terms of sound and light and how we can make these intangible elements quite tangible. This is what we have tried to achieve with KIMA to create a third or fourth dimension in between the two spaces, whereby just by light and colour and movement, we can say that people can use this as means of communication between them.

I think this is a very subtle element we are trying to explore and it's very complex as well. We only scratched on the surface here in this sense. I would definitely love to explore more, the idea of networked performances between different spaces via telepresence. This is why this development on KIMA is so important. The more responsive, intuitive and meaningful this experience is, the easier it is to feel the presence of the Other.

Would you say presence is a function of interaction, responsiveness and meaningfulness? Do you think meaning and presence are related?

I think this is quite important, from the perspective of how we perceive whatever is happening around us in the space, we are trying to assign meaning to whatever phenomenon we see. If you go back and think about historical or even religious notions of visions, it is always about interpretation: How do you interpret what you feel and what you see in the space. For it is important to try to reveal that meaning behind the actual interface, because otherwise presence becomes a technicality rather than meaningful communication.

From the point of view of a visitor, how would you describe the role of sound within the creation of presence?

I think the role of sound is incredibly vital, because it is almost like, as a visitor I am hearing that very remote echo, from a distance, maybe that voice that is travelling to me through 1000 thousands of kilometers and this voice can be very intimate. If I have an experience of singing together with someone, or the voice as any instrument, the expression, the vocal, sonic expression allows me to co-create through singing, playing an instrument together, or even if we are talking about more abstract sounds, through moving in space, and creating a soundscape, this soundscape becomes physical because sound is physical.

When something that is non-physical acquires some physicality... We cannot have touch in this case, when we are talking about telepresence via vision and sound. Sound makes this experience much more tangible.

So sound is a means of creation?

It definitely is. You are creating the space, you are creating a language. Once you don't see the other person but you have sonic feedback, only hear the voice, there are all sorts of things that come into play. So you become much more imaginative, and more likely to engage in the element of play as a participant.

So sound makes you more reflective?

Yes playful.

Sound fills the voice in the absence of physicality? In Kima we are contrasting stereo sound with immersive sound. On an experiential level, both as an artist and receiver how would you describe this difference?

Well I believe that immersive sound is working much more with our levels of understanding perception. Stereo sound is more for the ears, immersive sound is for me is for the body and the ears. With immersive sound you can really play with it in such a way that you can make it almost tactile. If we are playing with frequencies and we are trying to separate the frequencies in the space and start directing them, so when they move the sound moves. Then we are really talking about sound waves going directly through our bodies and especially if that immersive sound is also interactive, that means that with our movement we can almost be a composer, a director in real time.

Immersive sound is like a shower from all different sides, instead of showering my eardrums – I'm showering my whole self?

Does immersive sound become a sculpture?

It does become a space and a sculpture. The direction is from everywhere, so I can choose where in the space I want to move to have this experience – depending on how sound is distributed, to choose the experience.

With KIMA kinetic energy is transformed into sound,

If the participant is himself moving in the space, interacting with the space itself, they become more of a director of their actions, rather than a visitor. They start to direct their own experience – this is active participation. Hopefully, a person in this space will feel empowered rather than just sitting passively in a concert. Hopefully, apart from creating, we will be able to take sounds from participants and weave it into the overall sound design, so they can do improvisations themselves.

With KIMA we discuss the relationship between sound and geometry. How would you describe this relationship on a visual and perceptive level?

The whole idea of making sound visible in a geometric colourful visual way, it has been the basis for a lot of different work, we are not the first ones to try this route. The way KIMA works, we are trying to find a meaningful expression of geometric construction and progression of sound. We are trying to understand if there is an internal structure to sound and music and if so, how does it actually look, how does it move, not just on a screen, but how can it move inside the space. How does it organise the space, does it organise our conceptual space, our perceptual space and our visual space?

In this sense there is a very close link, and what we are doing is not just going off on a tangent, and say let's just draw circles, let's circles represent certain notes, certain colourful bars represent the duration of these notes, we are not trying to write another graphic score. We are not interpreting sound and geometry, we are trying to stay close to the physicality of sound and how the physical properties of sound when it bounces and pushes the matter, how can we make it visible, how can we see it. But at the same time, the project is not just a physical experiment of cymatics, it is also an artistic work. We are trying to see how can we get inside this pattern, how can we expand it to a macroscopic level. We are trying to create this cymatic work around us in the space, instead of just looking at it as observers. So we are becoming participants, part of this pattern, this vibration instead of just sitting back and enjoying how beautiful it looks. And that's where kinetic movement into play as well.

What is the relationship between artist, artwork and audiences in KIMA.

We are really trying to blur the boundaries between the three of them, so the artwork cannot happen without the audience. The artist on the other hand really disappears here. Artists is anyone who makes the sound, artist is anyone who works inside the project. We as artgroup who created that work step back, and allow people musicians, professional musicians, the audience, or whatever collaborations come about to be the artwork and be the artist in this case. It is quite an open relationship and hopefully it will grow like that.

How would you characterise is Analema Group? Art collectives have a very specific notion in art historic discourse, with Analema Group this collective seems to be expanding and contracting in various different ways. What is a collective in this context?

In this sense, the collective behind Analema Group is the heart of the project, it is almost like the heart that pushes the whole circulation around and that gives direction to the project. There are collaborators who will work with Analema Group in the future and these collaborations will happen but only because the core team of people actually moves the whole project towards a specific goal or a specific area. For example, we are choosing very carefully where we would like to go and where we want to see our projects happening. We are choosing the setting, the atmosphere, we are making a lot of artistic decisions, we are making a lot of technological decisions as well. We are limiting certain experiences, and we are almost the creative power behind it, in terms of shaping what kind of experience everybody would get. And this is also the collective, creative force: Everybody who is on this project, they always come with their own ideas of “by the way, why don’t we look at this particular development, this particular collaboration.” And I think this is the power of collaborative work, everybody really brings something really valuable into the project and not just playing specific functions, because sometime we are also blurring these functions and we can also change them, so there isn’t one person who does fundraising, someone does technical, we are all do everything together and are also giving creative input together. We do not separate between being an artist or being an accountant, all of us we are artists, but we are also having other functions we need to do – and in this case everybody has the chance to really express their creative potential.

The last question concerns the relationship between art and research in Kima:

I think the research element has played a big part in the development of KIMA. Artistic development and the academic research have both been feeding into each other and have been igniting each other. Academic research allowed us to publish the work we do, to get some amazing feedback from an academic aspect, at the same time, we reached out to an audience that might not experience the project, but may just read about it. It also helped us to focus and ask the right questions. We are not doing it for the sake of doing it, but we are doing it because we are researchers, even if not all of us are academic. We ask ourselves very specific questions, with this art project we are answering these questions – putting it into an academic perspective allows us to ground the project. By following a specific agenda, specific methodology, specific processes behind it, it focuses our attention much more. In the future I would like to expand our research, hopefully each of us can partially concentrate on specific research, feedback to the others, so to put it together and lift it to a higher level– I know you Oliver, will be continuing with your research, I would be very interested to research how music and sound affects us, on the therapeutic element and then putting it back into the art project. This allows to create a lot of overlap and nourishes the project from other spheres that surround it like satellites. Hopefully then this would allow us to share this findings with others who would invite us to show it in different settings.

Stelarc - Artist

Can you briefly describe your art practice and background?

As an artist I have always been interested in alternate ways of experiencing and performing with the body. Not only with its biological physiology but also augmented by prosthetics, robotics and virtual systems. In the '80s and early '90s I was performing with a virtual body using real-time motion capture and with a virtual arm, actuated by data-gloves.

What is a hologram for you?

Without resorting to any technical description I'd say a hologram, however generated, is a 3D optical construct that is a representation of objects or space that provides a real-world multiplicity of views of an object and an immersive experience of space.

What was your experience within the Musion Academy?

My experience with the Musion Academy was an excellent one. I would very much like to collaborate more in the future.

Can you describe one of your holographic art pieces?

The performance done in collaboration with Musion system was a performance in Second Life, performing with my avatar clones. This was done in collaboration with other artists in Australia and the USA who actuated my clones whilst I performed with my avatar from London. The animation of the avatars was a combination of real-time actuation and pre-programmed scripting. Using Musion provided a more potent presence of the avatars. Another Musion event was giving a presentation with my Prosthetic Head, which appeared beside me as a large floating head. We took turns in giving the presentation. And at times I could literally step inside my head. This presentation was also a play of scale- a counterpoint between a whole physical body and a much larger part of the body.

What is it that interests you as an artist about working with holograms?

Holograms are interesting for me because they problematise issues of presence and absence, of image and materiality. Also, holograms generate what I'd describe as "an optical aliveness".



Fig. 54 Stelarc Kinetica 2011

Cecile B. Evans – Artist

Can you briefly describe your art practice and background?

My work examines the value of emotion in contemporary society, and the increasing impact of digital technology on the substance of feeling and being. I originally trained as an actress, specialising in film and experimental theatre but have since developed a research based practice that is exhibited internationally, primarily in a museum and institutional context.

What is a hologram for you?

A hologram is an impossibility that the human brain wants to experience. When we see a holographic projection, using a technique like Pepper's Ghost, it's the viewer's mind that wills it to be present (and in 3D). I see it as a way for audiences to look at personal information (like the self and the body) in a different way and deeply engage with themes that have existed throughout history: immortality, materiality, etc.

What was your experience with holographic projections?

I first found out about holographic projections from a cartoon called Jem and the Holograms when I was a kid. This was also at a time when computers were being phased into primary schools. Something about this period of learning, coupled with an episode of Mr. Wizard's World (a science program) that was aimed at teaching young children how to make Pepper's Ghost that really sealed the deal.

Professionally, I worked with smaller holographic projections on an interactive guide project I made for Frieze and was toying with them as a hobby. I circled back to them last year when I was researching digital resurrection and replacement as well as looking into phenomena like Hatsune Miku. I continue to follow progress on new holographic technologies and hope to develop a live performance very soon.

Can you describe one of your holographic art pieces?

See above, more specific:

Frieze: I had a miniature holographic Simon Schama stationed inside embedded display units, throughout Frieze Art Fair to greet visitors at specific points in an audio guided tour I had developed.

I featured Yowane Haku (similar to Hatsune Miku), a holographic pop star from Japan in my last video Hyperlinks or It Didn't Happen.

What is it that interests you as an artist about working with holograms?

See above about expanding and engaging with themes--- more broadly, they become an engaging access point for otherwise difficult topics like death and immortality. It is also an effective method of exploring an audience's relationship to the digital as a something physical- evidence that both realms are very much of the same world. They are a way to help break down binaries like physical/digital and other more existential constructs- all while possessing a strong ability to be beautiful, touching, and funny all at once.

Technically, I love working with them to test the boundaries of what might be visually possible for audiences. What are the current limits of how they can experience moving image and how can those be disrupted?

Laura Jean Healey - Artist

Can you briefly describe your art practice and background?

Since graduating from Central Saint Martins College of Art & Design, where I specialised in 16mm film and installation, I have continued to inform and supplement my art practice by working within the art, fashion, and film industries as a Digital Camera Technician. Inspired by my extensive experience and technical understanding, I have become fascinated with the nature of the camera's gaze and use new digital film technologies - such as digital high-speed filming and holographic film projection - to create large cinematic film installations that seek to both engage and seduce my audience.

While my films draw upon the traditional cinematic visual language used within mainstream cinema, they also have a surreal and haunting quality. I like to find the beautiful and then draw out an element of the 'ugly' from within, to create a 'disturbingly beautiful' aesthetic, in which I am free to explore more obscure subject areas. In particular, I am fascinated by the role and objectification of the female form within film, the paradoxical nature of cinema exhibition and the desire it raises within the spellbound spectator.

What is a hologram for you?

To me a hologram is simply an illusion. At its very essence, a hologram is merely a projected light image – be it photographic or film - that appears to take on a 3-dimensional form and inhabit a real, physical, 3-dimensional space. We know that is not real, that it does not really exist, and yet when effectively crafted, it can make us feel as though there is something or someone really there, inhabiting the same physical space as us.

What was your experience within the Musion Academy?

I originally contacted Musion while researching a potential film installation project. I was invited to join the Musion Academy course and was introduced to their Eyeliner system, a digital reworking of the traditional Pepper's Ghost illusion. During the course, we were taught the basics for filming for this holographic technology and encouraged to develop our own creative projects.

As the course continued, I met many exciting and creative people from various backgrounds. Having experience as a freelance Camera Assistant within the film and television industry, I began to help other people on the course to film their projects, while continuing to develop my own work. It was a fun and creatively challenging space in which we were encouraged to think past how the technology was being used - at the time in more corporate arenas - and see if we could push the boundaries of the technology in innovative and exciting ways. One of my favourite projects was helping to film tigers at the London Zoo, for another artist's project, which was to help raise awareness for the work of the Zoological Society of London. We were also given the opportunity to exhibit our films as holographic installations at many high profile events, such as Kinetica Art Fair and the Shunt Vaults reopening.

I was then introduced to the Directors of the company and began to work as a freelance Camera Technician for Musion on many international projects. I was involved in some truly amazing and inspiring projects, such as the holographic film installation – in which a Ballerina turns into a crystal swan and then explodes into a flurry of butterflies – for the Yota sponsored after show party for the premiere of Mikailovsky's 'Swan Lake' at the

London Coliseum; filming Portuguese musicians for the holographic stage at the Optimus Alive Music Festival 2010; consulting on the very first Holographic Opera, 'Telesio', for the Italian Composer Franko Battiato, as well as assisting on the Mario Testino directed 'Burberry Body' installation for London fashion Week 2011.

It was an inspiring experience, in which I met some amazingly creative people - some of whom I have remained good friends with - who both inspired and challenged my art practice, leading to me developing a new line for investigation within my work.

Can you describe one of your holographic art pieces?

My most recent holographic art film project was 'The Siren'. It is a performance piece, filmed entirely underwater in slow motion. Playing to the theme that a hologram is merely an illusion, the film was inspired by the mythical tales told of Siren's throughout history. Men would tell these tales of beautiful and alluring creatures who would lure men to their untimely deaths, to warn of the dangers of the seductive female. The Siren, like her biblical counterpart Salome, became synonymous with the femme fatale and ultimately symbolises the female sex. She is simply a creation of man, merely a sexed being. She does not exist in her own right and has no voice of her own.

'The Siren' therefore, uses the image and plays to the preconceived notions of this mythical temptress to explore the true nature of the audiences gaze, their innate desire to watch and how the female form is represented in art and film. By playing to and embodying these traditional clichés - beautiful, dangerous and always naked - the film seeks to both challenge these sexual clichés and to finally give a strong and powerful voice to the Siren.

Filmed entirely underwater in slow motion and projected as a life size holographic film installation, the film turns the Musion Eyeliner stage into a large underwater tank, in which the impossible - a women living and breathing underwater - seems to become a reality. Like her mythical sisters, the Siren does not really exist and yet she is able to meet, hold and challenge her audiences' gaze. Beautiful and haunting, she *exists* only within the substantial nothingness of the screen as pure artifice and constructs her own reality, in which she transcends these sexual clichés attached to the perception of the Siren and forces her audience to not only acknowledge and accept her presence, power and autonomy over them, but to question who is in control of the gaze: the watcher or the watched?

What is it that interests you as an artist about working with holograms?

As an artist, I am inspired by the work of the film theorist, Tom Gunning, who likened the early cinema to that of a 'Cinema of Attractions', in which the projected image exists as pure spectacle. When projected, film - especially now that we are increasingly using digital film formats - is an intangible and ephemeral light source. It only appears to become real, or tangible when it is projected against a screen and it is in this moment that an ontological paradox occurs between the physically real space of the screen (and auditorium) and the projected moving light image. It is this paradox that I find to be the most exciting, as the light image in this moment exists as a pure *spectacle*. It openly and unashamedly solicits the audience's inherently voyeuristic gaze and in doing so encourages their curiosity to look. Through watching any film projection, be it in the cinema auditorium, on a laptop, iPad, or television screen, we seem to believe that we can in some way consume or perhaps even own the moment being screened before us. The camera, when used effectively, draws the audience into the moment and in doing so, they are made to feel as though they are right there in the moment, experiencing what the characters on the screen are experiencing. But in truth, this is one big fallacy that we knowingly seek out again and again in order to derive a false sense of - unfulfilling - pleasure from; as to look is to desire, and to desire is to intrinsically lack. This sense of loss is heightened even further when working with Musion's eyeliner system, as the illusion is designed to make people knowingly believe that someone or something is there, when in reality, they are merely a cleverly refracted light image, that

seemingly takes on a *real* presence. When effectively employed, you can make the audience feel as though someone, like the Siren, is really there in the room with them, luring the audience to look, but in reality, there is nobody there at all.

Rachel Garrard – Artist

Can you briefly describe your art practice and background?

I was born in 1984 in Devon, England, and live and works in New York. While completing my graduate studies at Central Saint Martins in 2009, I gained recognition for performance-based refracted-video works such as *Circuition* (2009), and *Seven Transmutations* (2010). My work has been shown internationally in curated exhibitions, art fairs, and private galleries. These venues include Jack Hanley(NYC), Shizaru(London), Participant Inc (NYC), Frieze Art Fair (2012, London and NYC), Spring/Break(NYC), Yota Space(St. Petersburg), Kinetica Digital Art Fair(London), Eyebeam(NYC), and Bruce High Quality Foundation's Field of Dreams(NYC), a solo show at Untitled Art Fair (Miami Beach), and a solo show with exhibition catalogue at Gasser Grunert(NYC). I was awarded artist residencies at the Atacama Telescope Farm in Chile in 2011, and the Center for the Holographic Arts at Ohio State University in 2012. I was awarded second place at the Holographic Projection Art Awards, London in 2012 and 2010 and first place in 2009.

My work as a visual artist seeks to transcend media, ranging from live performance and holographic projections, to flat etchings, silverpoint drawings and sculptural installations. Although I draw intellectual inspiration from traditional devotional practices and ancient concepts of geometric order, all of my projects tend to reflect a distinctly modern approach. It is my wish to both continue along and refine this current trajectory, with the goal of creating art that challenges notions of presence. Through my work as a studio artist, I aim offer viewers the opportunity to contemplate their own awareness.

What is a hologram for you?

A hologram shows the aspect of reality that the whole is contained within each of its parts.

What was your experience within the Musion Academy?

Having come across Musion academy quite by accident during my research into the creation of holograms, I was very happily surprised to be welcomed into the academy, where I was able to experiment with the technology and equipment. After learning the basics I worked on many projects with Musion creating pieces to be showcased at Kinetica Art Fair and Yota Space in Russia. Oliver Gingrich who has been heading Musion academy because a great friend and vital part of many of my projects.

Can you describe one of your holographic art pieces?

Based on the notion that everything is temporary and in flux, 'Circuition' attempts to portray the internal cycles of the psyche, projecting psychological experiences onto the external reality of the body. Through holographic projection via the Musion screen, multiple transitory human forms, mass less but with momentum, together perform a repetitive psychic and physical cycle. Holography can be used to mimic a presence, uncanny yet vividly real, ephemeral yet imbued with permanence. Using the naked human form, 'Circuition' refashions the concept of the original, challenging authenticity while juxtaposing it with that of the false and the duplicated. The body merges with a reflection of itself. One image gives rise to many fragmented iterations. 'Circuition' is where the artist becomes the artwork, the spectator becomes an interactive audience and

the empty space is given the illusion of solidity. Reality is evoked by a transient image, much as it is in real life. 'Circuition' is accompanied by a 5-point surround sound installation which has been recorded in collaboration with sound specialist Daniel Biro.

What is it that interests you as an artist about working with holograms?

My initial fascination with holography came from my research into Quantum Physics, metaphysics and consciousness research. I was introduced to the work of David Bohm and his analogy of the hologram to the implicate nature of reality, that each part of physical reality contains the information of the whole. This also led me to the work of Karl Pribram who believes that the brain works in a similar manner to a hologram, storing information later to be projected on recollection. Starting with these scientific perspectives, I noticed that this idea of an illusive physical reality is by no means a new idea. Many of the ancient belief systems such as Hinduism called physical reality Maya, an illusion, created by consciousness.

I wanted to translate these concepts into my art work, so started to research holography as an artistic medium. At first I started working with Igor Aleksander, professor of neuroscience at Imperial College London, and then with his associates in the Optical Sciences department. We initiated a project to create a 3-dimensional moving hologram using laser beams. However the limited technology at the time meant that the resulting image would be no more than 1 1/2cms in scale. I then found and began to work with Musion Academy who are at the forefront of holographic projection, and began to work on projects that challenge our normal perception and through the refraction of projected light, causes us to become accustomed to perceiving something physically intangible. Using the 3-dimensional illusory representation of something that is normally imperceptible, the archetypal forms of the underlying deeper order of existence can be made visible

Steff Unger / New Opera Hero - Artist

Can you briefly describe your art practice and background?

I studied photography and film design in Germany and Holland before teaming up with a partner in the UK to start a company that specialises in audio and visual content for live events. Parallel to that I created opera, theatre and stage performances which over the last few years have taken the shape of a band called New Opera Hero in which technology, storylines and design are merged with live music.

What is a hologram for you?

Because of our long standing relationship with Musion I have accepted the 'startreck beam look' as being 'holographic'. That means that I don't care about the actual technology but accept any image that seems to be three dimensional and projected in space without apparent screen surface. Pepper's Ghost and other technique qualify if done correctly. Important is the effect on the viewer.

What was your experience within the Musion Academy?

The Academy gave us a great platform to present our experiments with the Musion screen and was essential as a playground to discover the possibilities of the technology. It was also very useful as a meeting point to find similarly minded artists and for potential commercial jobs based on the artistic work.

Can you describe one of your holographic art pieces?

We have mainly created environments and objects around performers. Examples for this

are projected pin wheels that were blown by musicians on stage, a projected toy pile with a live performer at the centre of it, arms engulfing a performer and an animated head with 2 singers inside. The pieces are connected by a storyline and are part of a 60minute journey through the life of a giant baby.

What is it that interests you as an artist about working with holograms?

Our main interest has always been the possibility to extend the space around a performer and to be able to initiate scene changes in the fraction of a second. This enables a storytelling rhythm in live performance that has been restricted to film with its cutting techniques in the past..

Gaelle Berton - Artist

Can you briefly describe your art practice and background?

I am an Interaction Designer, Visual and Digital artist as well as a Director

What is a hologram for you?

An hologram is a 3D visual illusion, whether the illusion be the third dimension, the motion or placement, it feels both reel and eerie.

What was your experience within the Musion Academy?

Great, using the material and technology there is great, and they expect professional quality and still allow the artist to be faithful to his original idea. Oli has been out of his way to ensure the project would be successful. Working with Musion allowed me to meet other artists and professionnla working on the same support, it was indeed an invaluable experience.

Can you describe one of your holographic art pieces?

My first piece, WiiAct! An interactive augmented reality piece, with a dancer/performer on stage triggering and controlling graphics with a wiimote control.

What is it that interests you as an artist about working with holograms?

This is the perfect support for augmented reality, it also has a stage/theatre dimension to it, and the wow factor on the spectator side upon first impression.

Madi Boyd - Artist

Can you briefly describe your art practice and background?

I studied at The Slade, UCL, from 2001-2005. Prior to that, I studied History at Edinburgh University. My practice involves moving image projection installation. I combine moving image with constructed environments so that the two form one visual or multi-sensory experience. I often collaborate with scientists and psychologists to research and create the work.

What is a hologram for you?

My understanding of a hologram is a specific type of image, created through a particular process using refracted light.

What was your experience within the Musion Academy?

It was a very creative space. We were free to experiment with the technology in any way we wanted, there was no particular brief, which was important, and very freeing. We were able just to push the technology in any way we wanted. We also shared our work with each other and made connections or networks, particularly through presentations and talks. The Musion awards provided both a deadline and a sense of purpose to our work with the technology.

Can you describe one of your holographic art pieces?

I created a performance piece, which combined the Musion illusion with reality. One of my sculptures involves many strings that I project onto. I constructed, on stage, a version of this sculpture by attaching strings to the ceiling and floor and projecting onto them as done in the original artwork. Around this sculpture I created a holographic film, which utilised footage of the original sculpture. During the duration of the holographic film, I cut the strings of the stage construction (from above so I wasn't seen on stage). This removed the reality and left only the illusion on stage.

What is it that interests you as an artist about working with holograms?

My impossible dream is to be able to work with totally 3D film in space. Musion holograms are the closest I have come to this. I also like the effect that the musion screen has on the film clips – for example it is possible to make something look like an object on stage but it can be whatever size you want it to be. (In my ink film, seemingly giant drops of ink fall from the ceiling, this would be very difficult to achieve in reality.)

Tony Langford – Founder and Director of Kinetica

Can you briefly describe your background?

I am co-founder and director of Kinetica Museum and have coordinated and managed the annual programme of events at Kinetica Art Fair, encouraging and promoting collaboration and cross-over between artists, performers, scientists, technologists and academics.

-Researcher on European Parliament Culture Committee, 1996-8

-Masters in Interactive Multimedia from London College of Communication, 2002.

Currently working with researchers from Cardiff Metropolitan University and Queen Mary University on the creative application of new technologies to improve self-awareness and wellbeing.

What is a hologram for you?

An image visible in three dimensions or that has a depth beyond those projected on conventional flat screens or surfaces

What was your experience within the Musion Academy?

Very positive, an opportunity for artists to experiment with a unique technology and to create innovative performances

Can you describe one of your favourite holographic art pieces?

Laura Healey's piece filmed in water was very memorable in terms of cinematic effect. Most of my favourite pieces were the ones that exploited the possibilities for interplay between live performer and virtual imagery, such as with New Opera Hero and Ki-Ra.

What is it that interests you as an artist about working with holograms?

Exploring the ambiguities around what is real and what is virtual or imagined. With a 'perfect' hologram then in theory the two are indistinguishable.

Kira Zhigalina / Ki-Ra – Artist

Can you briefly describe your art practice and background?

I graduated from Central St. Martins in 2008. My practice has always been predominantly film and video. I like to create emotional experience for the viewer with aesthetically pleasing ethereal work that derives from innermost places.

I created installations and projections for Secret Cinema, London Contemporary Orchestra, London Zoo, Vivienne Westwood show, Fruit for the Apocalypse, Unfashion Show, ROH, LSO and the Rambert Dance Company. Kira won Kinetica Award in 2012 at Kinetica Artfair, and in 2010 she won an award for performance at MAMAs 2010.

What is a hologram for you?

It is an alternative reality

What was your experience within the Musion Academy?

It has given me a great opportunity to experiment with holograms, and work in collaboration with other artists and amazing clients like ZSL.

Making commissions and working on such projects as climate change and endangered species in the context of producing a holographic work, was a fantastic experience. It has also given me space to create my own work with amazing support and encouragement from Oliver)

Can you describe one of your holographic art pieces?

Ephemeral Lightness of Being was an experiment using el wire and live feedback loop on the hologram creating a distorted trail effect on the live performer.

The piece explores the concept of the self in its different levels, such as human energy field and the human emotional journey that exists as a shape-shifting color light trail, temporarily created in collective space. The work meditates on the original state of nature that is driven by chaos, organizing into fractal beams of consciousness.

What is it that interests you as an artist about working with holograms?

Holograms have an immense potential for live performance, and video work to expand the one dimensional experience of the viewer.

12.1 Further Practical References:

KIMA at Kinetica

<https://www.youtube.com/watch?v=YSQaGcWmW7E>

KIMA at Musion

<https://www.youtube.com/watch?v=LCjwm1jbvAE>

KIMA at Watermans center for digital art

<http://analemagroup.wordpress.com/2014/03/18/kima-performance-at-ict-art-connect-at-watermans-art-centre-in-london/>

KIMA at Festival of Learning Bournemouth

analemagroup.wordpress.com/2014/03/23/kima-at-festival-of-learning-at-bournemouth-university-9-12-june-2

KIMA at Union Chapel

<https://www.youtube.com/watch?v=PatNkvxByzc>

Transmission Pilot Tests

<https://youtu.be/y5LNmjUqFdM>

Aura Prototype

<https://youtu.be/QvsQERsfPJI>

12.2 Contributions of Team Members

Case Study 1 - KIMA:

Conceptual Development

Oliver Gingrich 30%

Eugenia Emets 30%

Alain Renaud 30%

Joe Pochcio/ Anna Buonomo/ Lani Rocillo 10%

Artistic Development

Oliver Gingrich 30%

Eugenia Emets 30%

Alain Renaud 30%

Joe Pochciol/Johnny Stutters 10%

Sound Design

Alain Renaud 80%

Eugenia Emets 20%

Technical Setup

Oliver Gingrich 30% (Projection, Display environment, Lighting design)

Alain Renaud 30% (Networking, Sound distribution)

Eugenia Emets 30% (Software and motion tracking, sound input)

Joe Pochcio/Jonny Stuttersl 10%

Research Design – Oliver Gingrich Input 100%

Development of Research Design (qualitative analysis, interviews)

Development of Questionnaire

Evaluation of Questionnaire

Case Study 2 - Transmission:

Conceptual Development

Oliver Gingrich 30%

Eugenia Emets 30%

Alain Renaud 30%

Szymon Kalinski 10%

Artistic Development

Oliver Gingrich 30%

Eugenia Emets 30%

Alain Renaud 30%

Szymon Kalinski 10%

Sound Design

Alain Renaud 80%

Eugenia Emets 20%

Technical Setup

Oliver Gingrich 25% (Projection, Display environment, Lighting design)

Alain Renaud 25% (Networking, Sound distribution)

Eugenia Emets 25% (Software and motion tracking, sound input)

Szymon Kalinski 25%

Research Design – Oliver Gingrich Input 100%

Development of Research Design (qualitative analysis, interviews)

Development of Questionnaire

Evaluation of Questionnaire

Case Study 3 – Aura

Conceptual Development

Oliver Gingrich 40%

Eugenia Emets 30%

Alain Renaud 30%

Artistic Development

Oliver Gingrich 50%

Eugenia Emets 25%

Alain Renaud 25%

Technical Setup

Oliver Gingrich 100% (Projection, Display environment, Lighting design)

Research Design – Oliver Gingrich Input 100%

Development of Research Design (qualitative analysis, interviews)

Development of Questionnaire

Evaluation of Questionnaire

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12.5 Glossary

ISPR - International Society for Presence Research

ITQ – Immersion Tendency Questionnaire

PQ – Presence Questionnaire

STM – Standard Telepresence Model

SUS – Slater, Usoh & Steed Questionnaire

UQO – Université du Québec en Outaouais

12.6 Presence Questionnaire

Presence Questionnaire

1. How much were you able to control events?
2. How responsive was the environment to actions that you initiated or performed?
3. How natural did your interactions with the environment seem?
4. How completely were all of your senses engaged?
5. How much did the visual aspects of the environment involve you?
6. How much did the auditory aspects of the environment involve you?
7. How natural was the mechanism which controlled movement through the environment?
8. How aware were you of events occurring in the real world around you?
9. How aware were you of your display and control devices?
10. How compelling was your sense of objects moving through space?
11. How inconsistent or disconnected was the information coming from your various senses?
12. How much did your experience in the virtual environment seem consistent with your real world experiences?
13. Were you able to anticipate what would happen next in response to the actions that you performed?
14. How completely were you able to actively survey or search the environment using vision?
15. How well could you identify sounds?
16. How well could you localise sounds?
17. How well could you actively survey or search the environment using touch?
18. How compelling was your sense of moving around inside the virtual environment?
19. How closely were you able to examine objects?
20. How well could you examine objects from multiple viewpoints?
21. How well could you move or manipulate objects in the virtual environment?
22. To what degree did you feel confused or disoriented at the beginning of the session or at the end of the experimental session?
23. How involved were you in the virtual environment experience?
24. How distracting was the control mechanism?
25. How much delay did you experience between your actions and expected outcomes?
26. How quickly did you adjust to the virtual environment experience?
27. How proficient in moving and interacting with the virtual environment did you feel at the end of the experience?
28. How much did the visual display quality interfere or distract you from performing assigned tasks or required activities?

KIMA – Witmer and Singer presence questionnaire

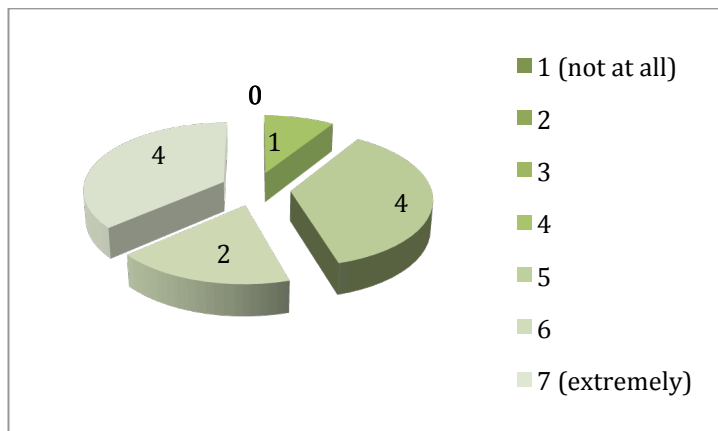
12.7: Evaluation KIMA - Presence Questionnaire

		Frequency	Total Score	Mean	Nr. of Questions	f		
1	Control	11	64	5.8	19	110.2	Interaction	CF
2	Responsive	11	66	6	19	114	Interaction	CF
3	Natural	11	81	5.8	19	110.2	Realism	CF
4	Visual Involvement	11	67	6.1	19	115.9	Realism	SF
5	Natural Mechanism	11	61	5.5	19	104.5	Realism	CF
6	Objects in Space	11	60	5.5	19	104.5	Realism	SF
7	Consistency	11	63	5.7	19	108.3	Realism	RF, CF
8	Anticipation	11	53	4.8	19	91.2	Interaction	CF
9	Survey vision	11	58	5.3	19	100.7	Interaction	RF, CF, SF
10	sense of moving	11	62	5.6	19	106.4	Realism	SF
11	Examine objects	11	62	5.6	19	106.4	Examination	SF
12	multiple viewpoints	11	65	5.9	19	112.1	Examination	SF
13	Involved	11	73	6.6	19	125.4	Realism	CF
14	Delay	11	58	5.3	19	100.7	Quality	CF
15	Adjusting	11	64	5.8	19	110.2	Evaluation	
16	Proficiency	11	68	6.2	19	117.8	Evaluation	CF
17	Display	11	63	5.7	19	108.3	Quality	DF
18	Control Device interference	11	57	5.2	19	98.8	Quality	DF, CF
19	Concentration	11	61	5.5	19	104.5	Examination	DF
20	Sound	11	58	5.3	19	100.7	Sound	SF
21	Sound identification	11	63	5.7	19	108.3	Sound	RF, SF
22	Sound localisation	11	64	5.8	19	110.2	Sound	RF, SF
23	Touch	11	19	1.7	19	32.3	Touch	RF, SF
24	Manipulation	11	60	5.5	19	104.5	Touch	CF
	Average		61.4	5.58	SD	0.868657569023733		
	Total		1412	131.9	Grand Mean	5.49		

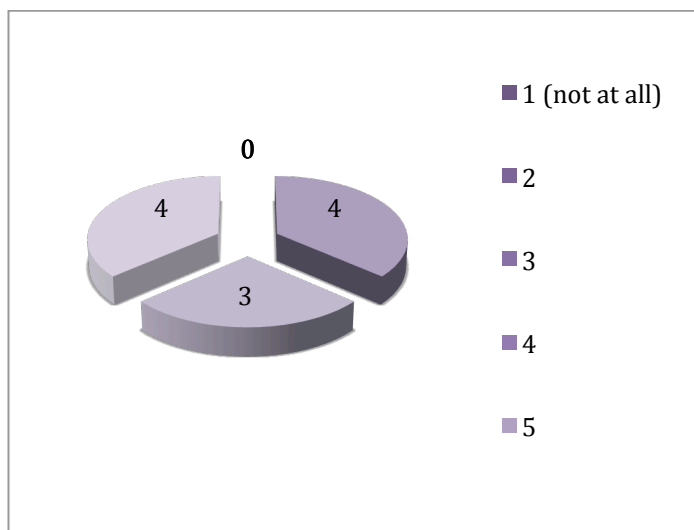
Presence questionnaire Clusters

12.7 Evaluation KIMA – Presence Questionnaire

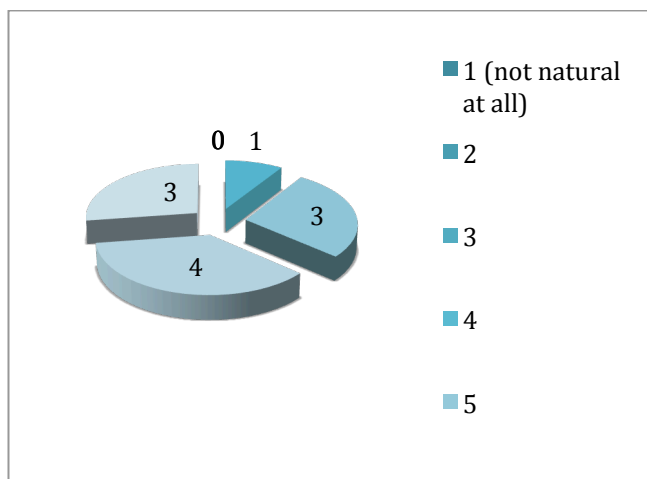
1. How much were you able to control events?



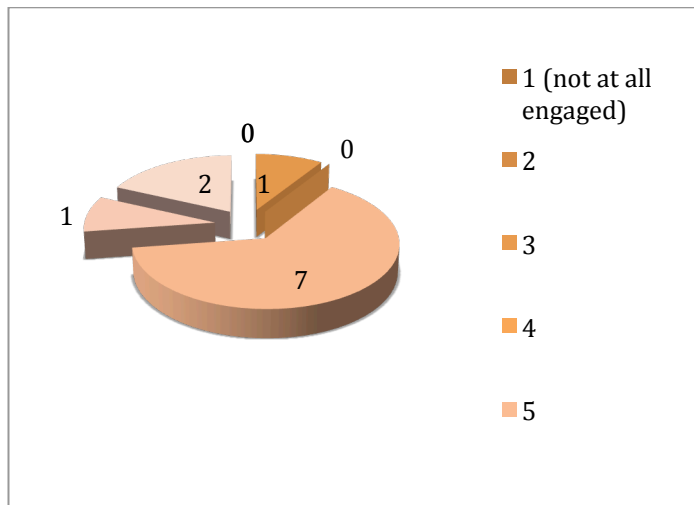
2. How responsive was the environment to actions you initiated?



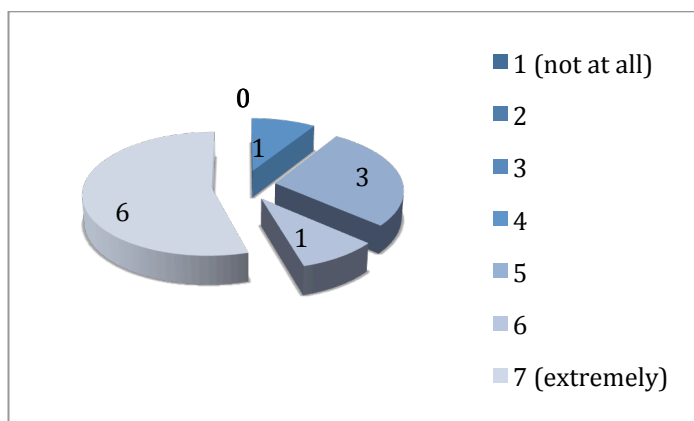
3. How natural did your interactions with the environment seem?



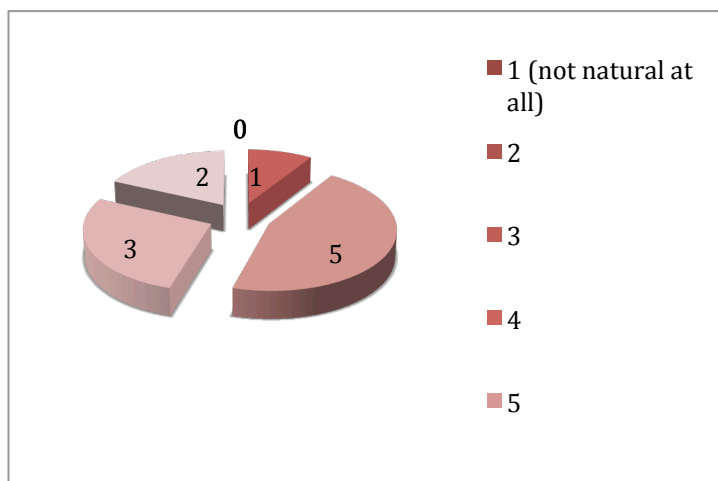
4. How completely were all of your senses engaged?



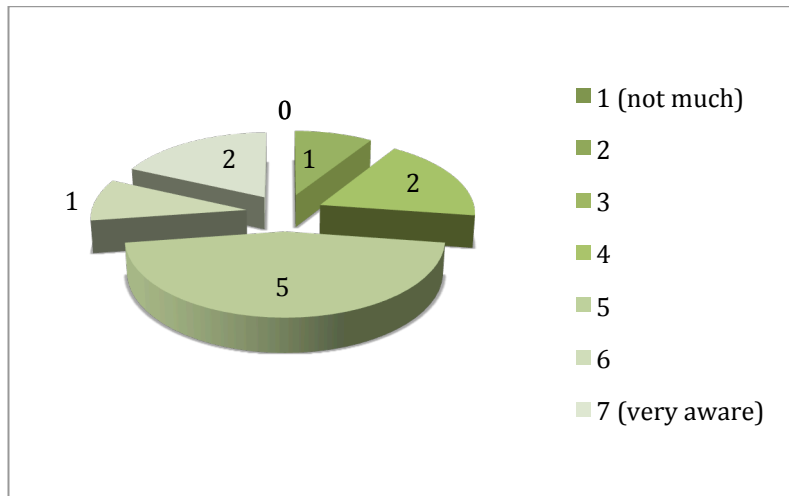
5. How much did the visual aspect of the installation involve you?



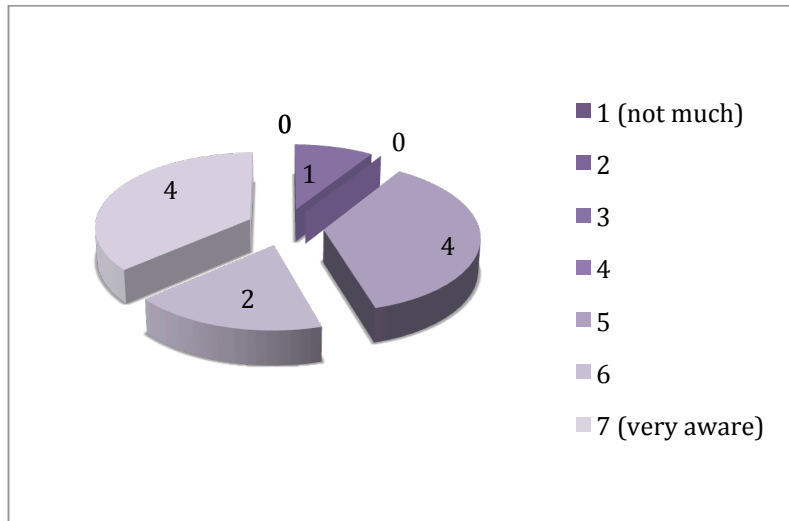
6. How natural was the mechanism, which controlled movement through the environment?



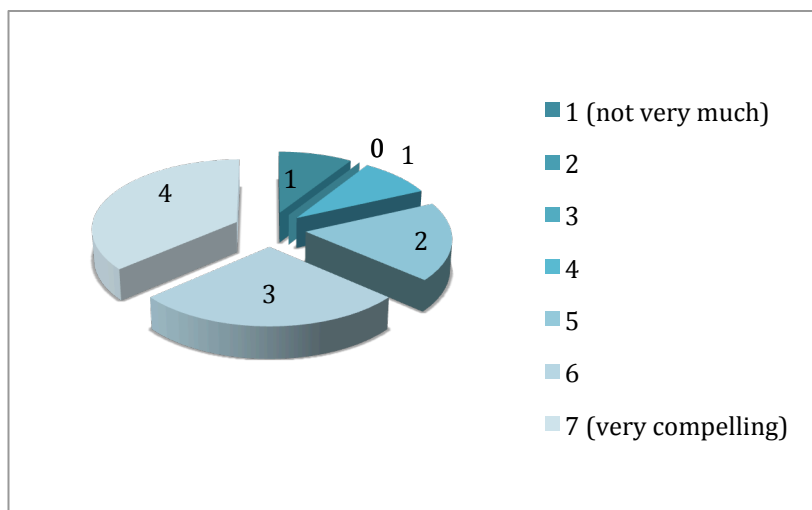
7. How aware were you of events that occurred around you?



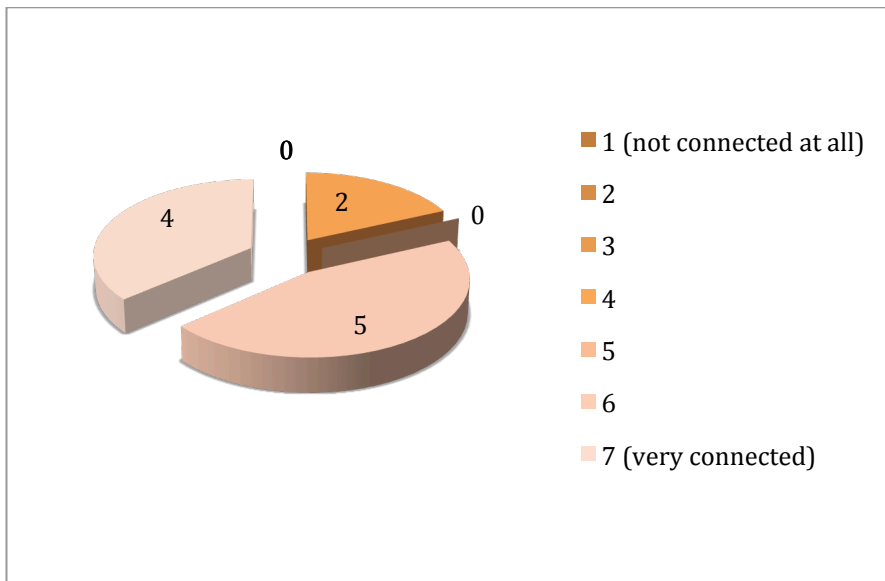
8. How aware were you of your display and control devices?



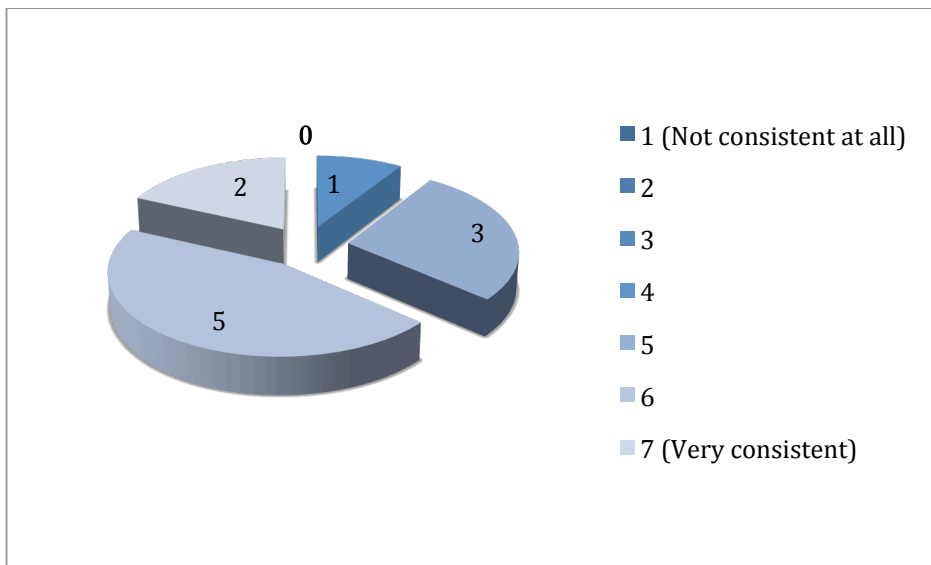
9. How compelling was your sense of objects in space?



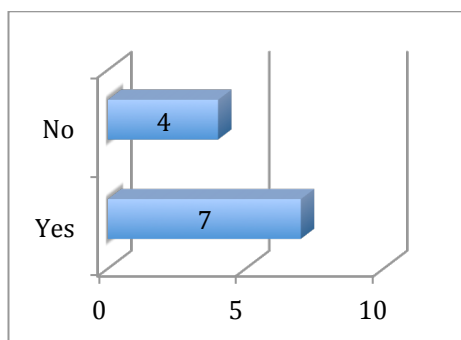
10. How inconsistent or disconnected was the information coming from various senses?



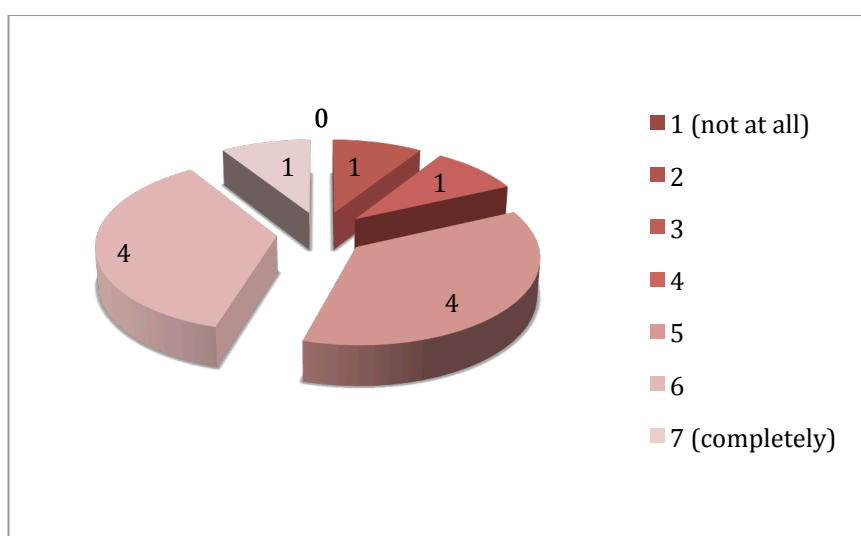
11. How much did your experience in the virtual environment seem consistent with your real world experience?



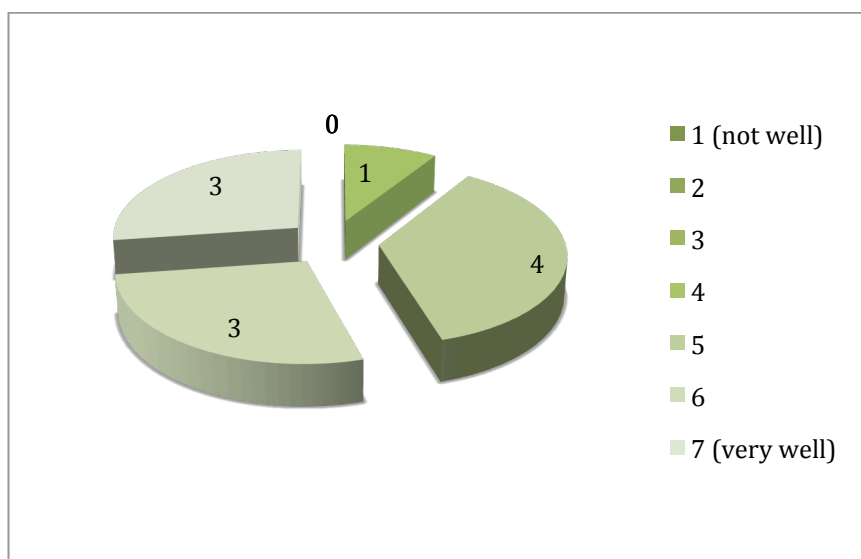
12. Were you able to anticipate what would happen next in response to the actions you performed?



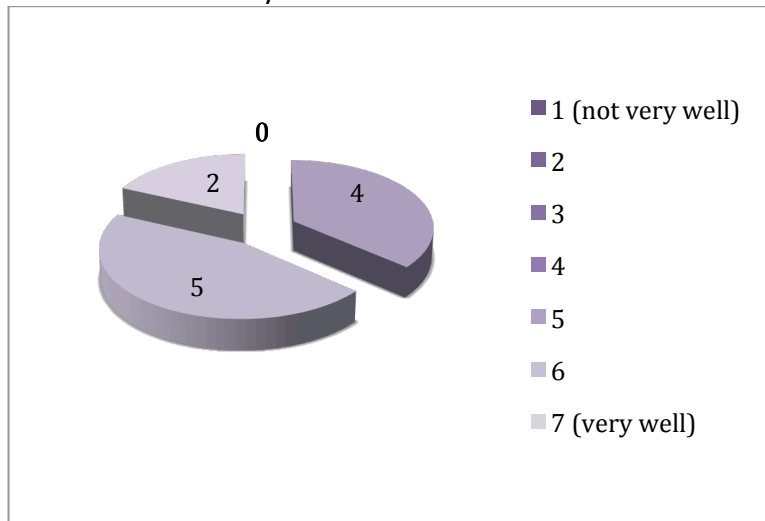
13. How completely were you able to actively survey the experience using vision?



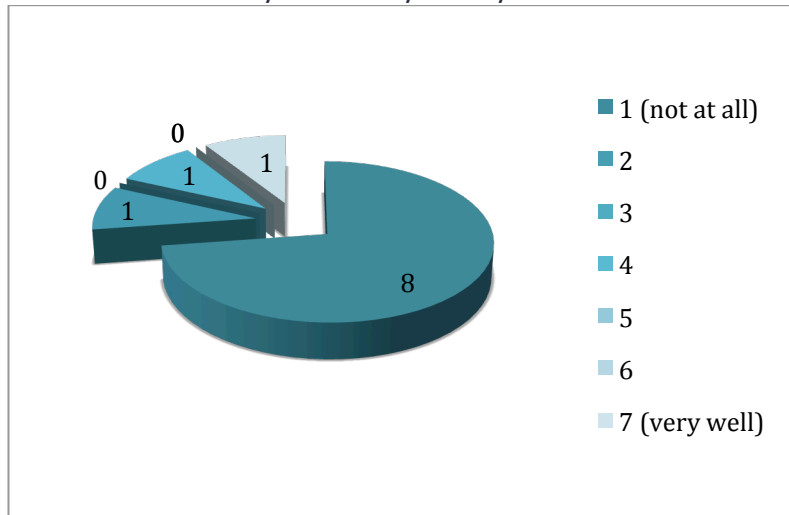
14. How well could you identify sounds?



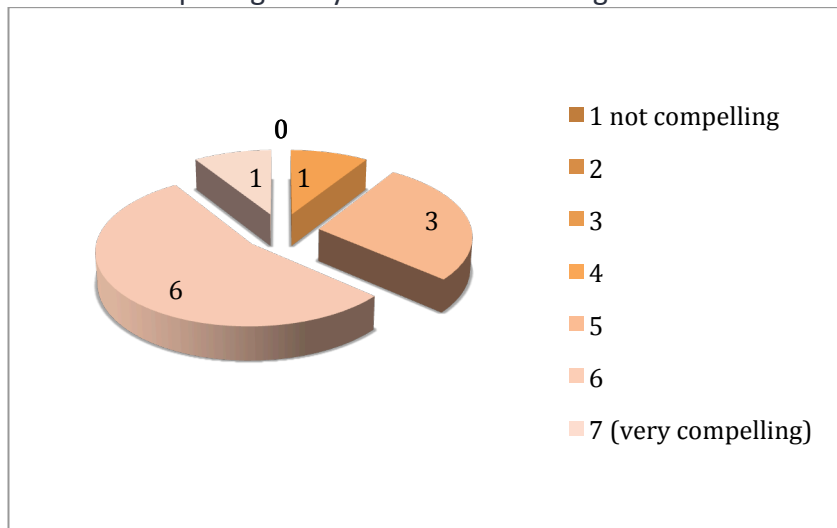
15. How well could you localise sounds?



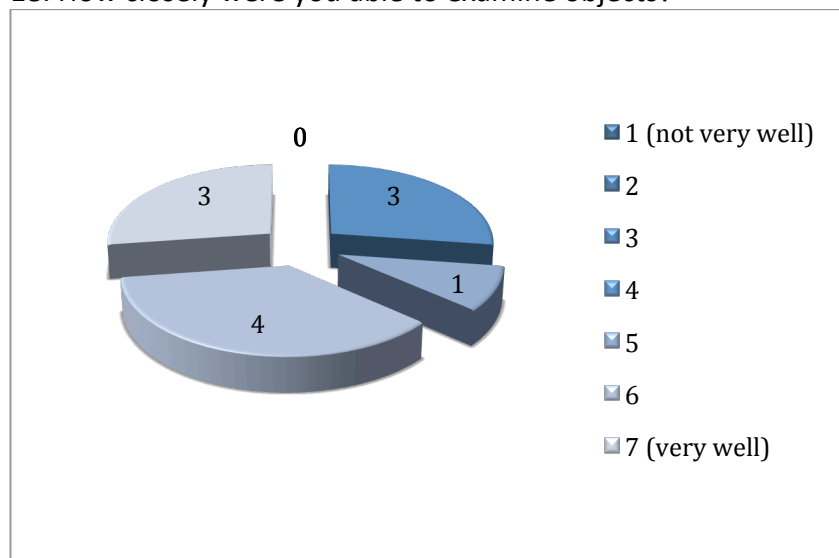
16. How well could you actively survey the virtual environment using touch?



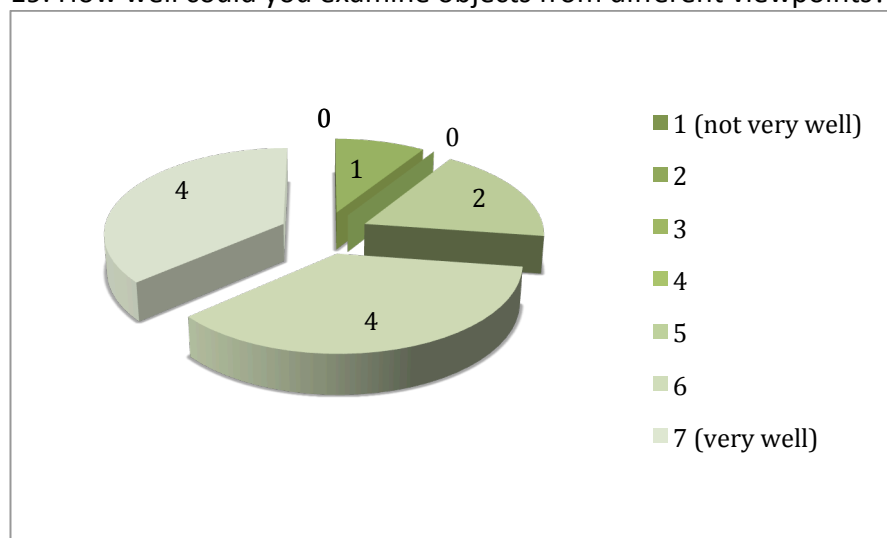
17. How compelling was your sense of moving around inside the environment?



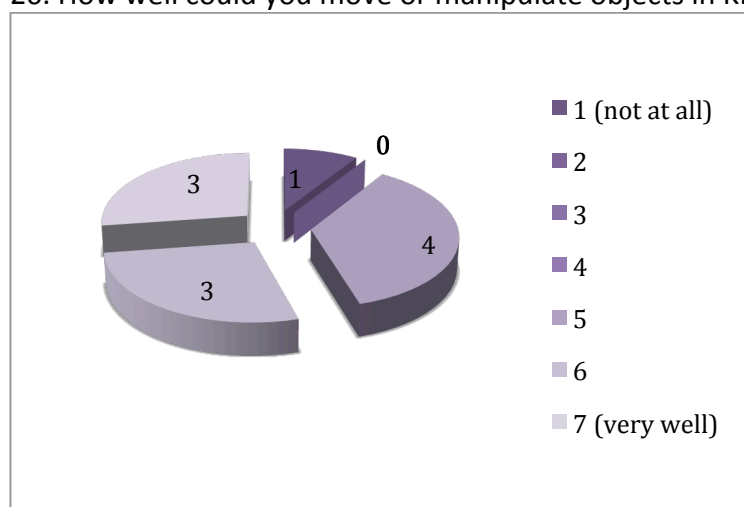
18. How closely were you able to examine objects?



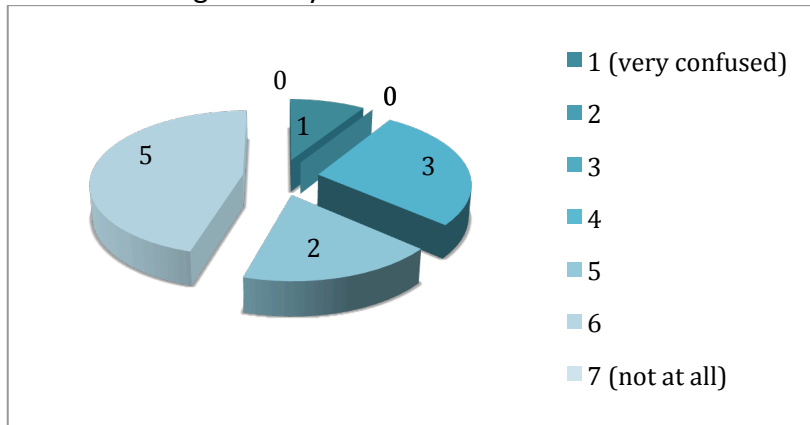
19. How well could you examine objects from different viewpoints?



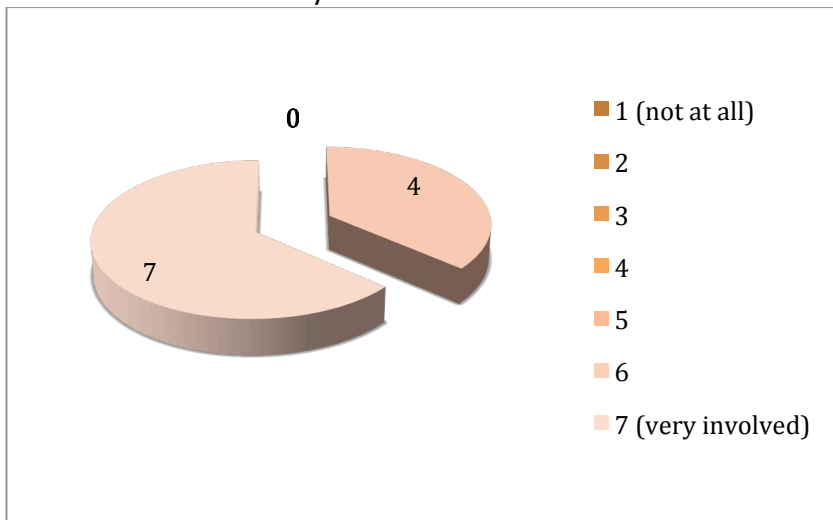
20. How well could you move or manipulate objects in KIMA?



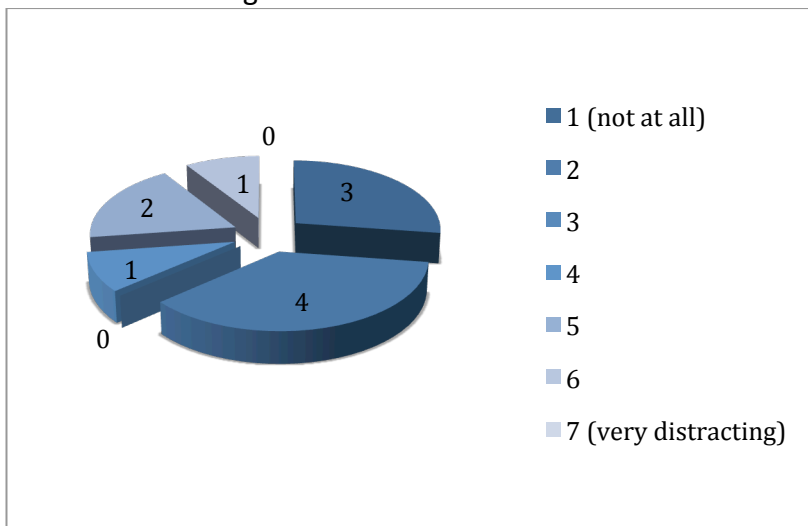
21. To what degree did you feel confused?



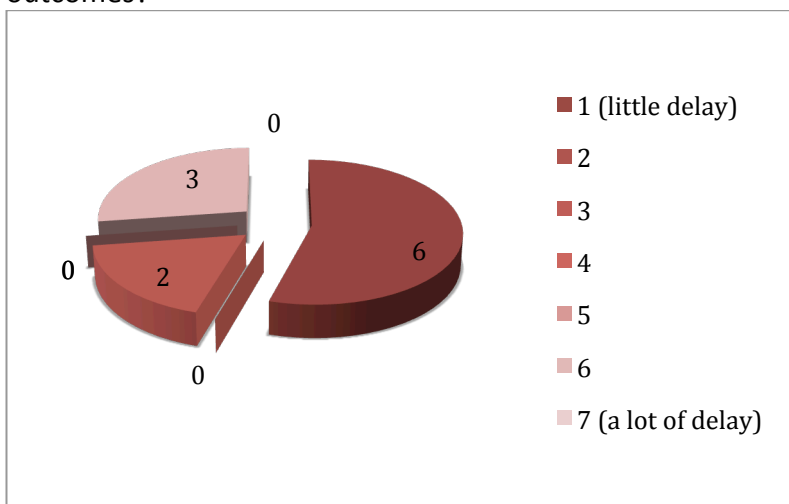
22. How involved were you in KIMA?



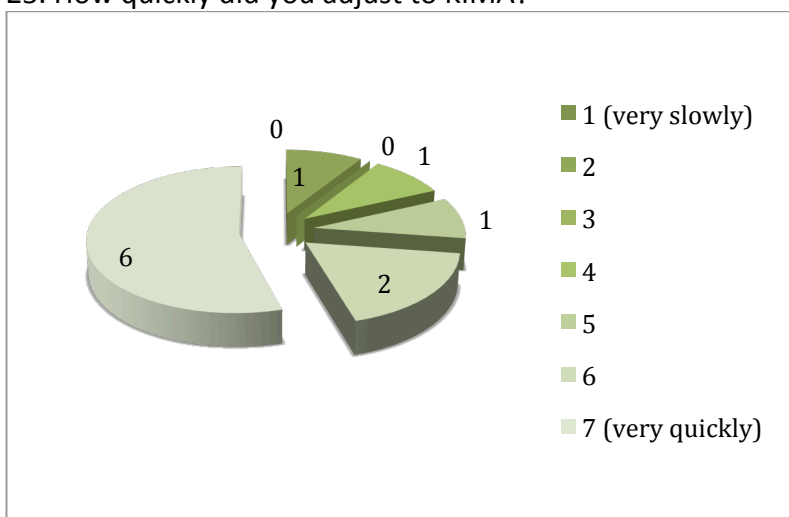
23. How distracting was the control mechanism in KIMA?



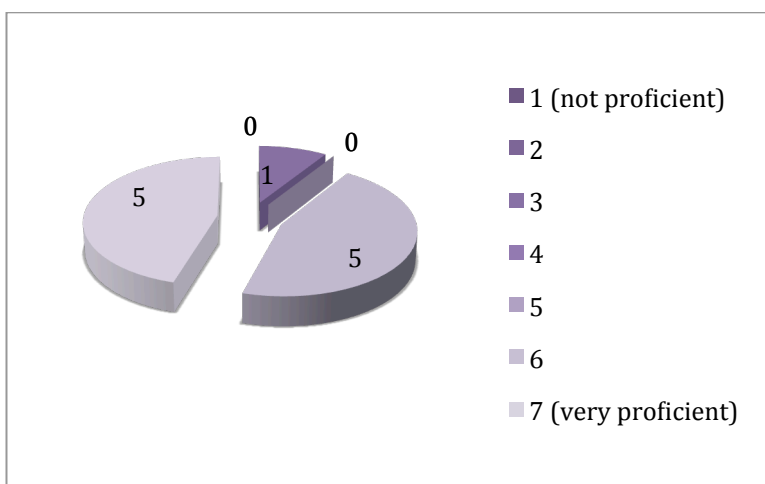
24. How much delay did you experience between your actions and expected outcomes?



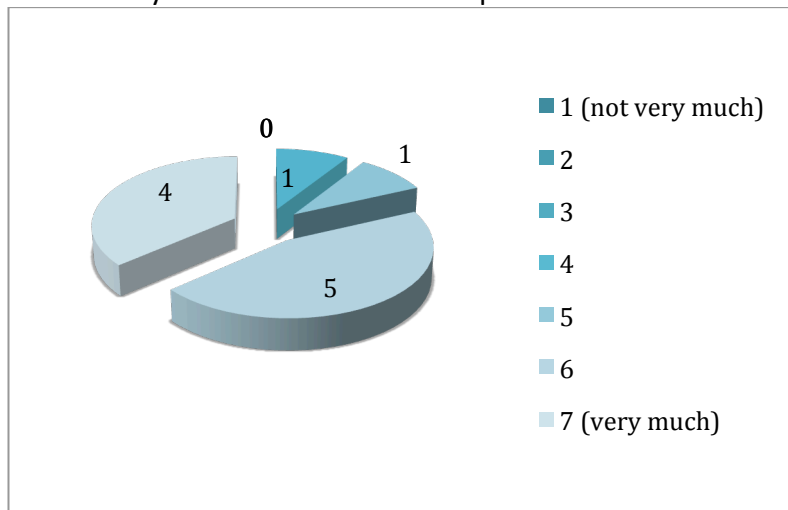
25. How quickly did you adjust to KIMA?



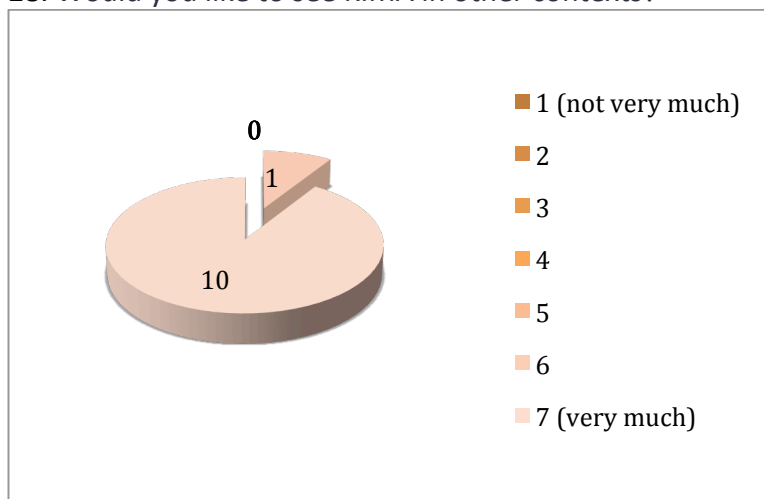
26. How proficient in interacting with KIMA did you feel at the end of your experience?



27. Would you like to see KIMA as a performance?

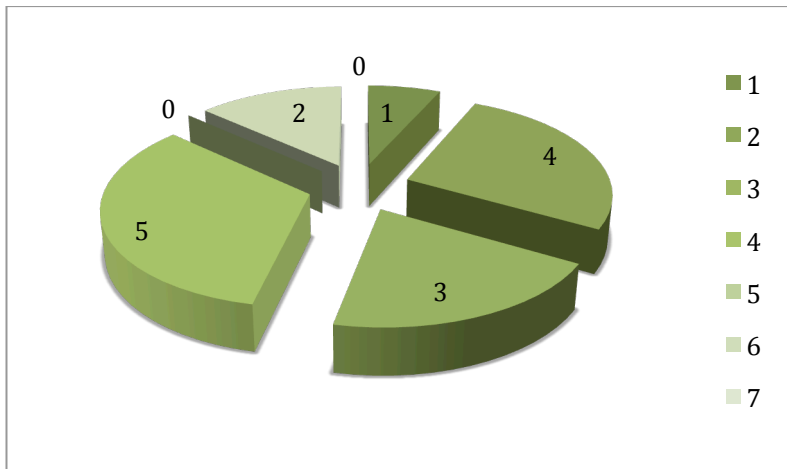


28. Would you like to see KIMA in other contexts?

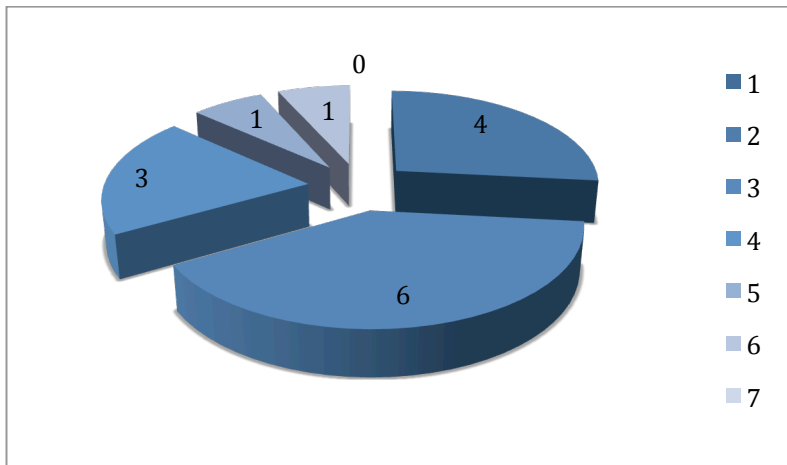


12.8 Evaluation Transmission - Presence Questionnaire

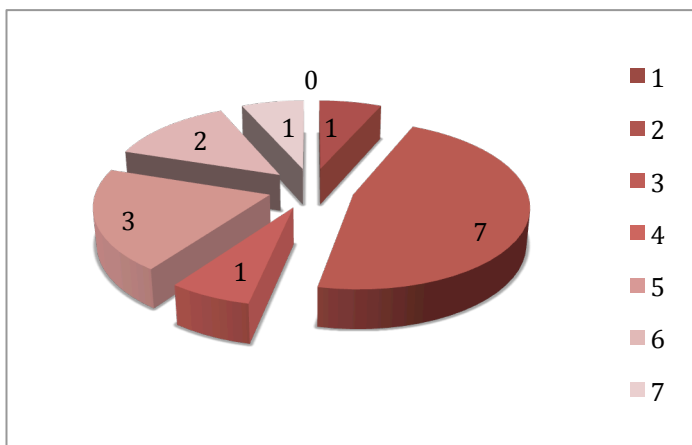
1. How much were you able to control events? 1= not at all; 7 = extremely



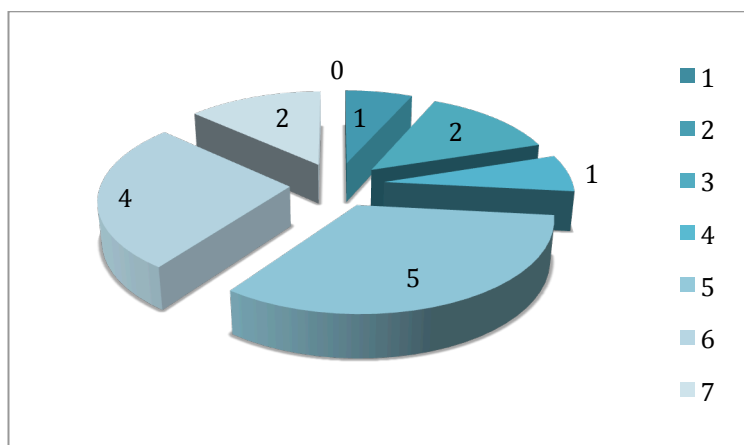
2. How responsive was the environment to actions you initiated? 1= not at all; 7 = extremely



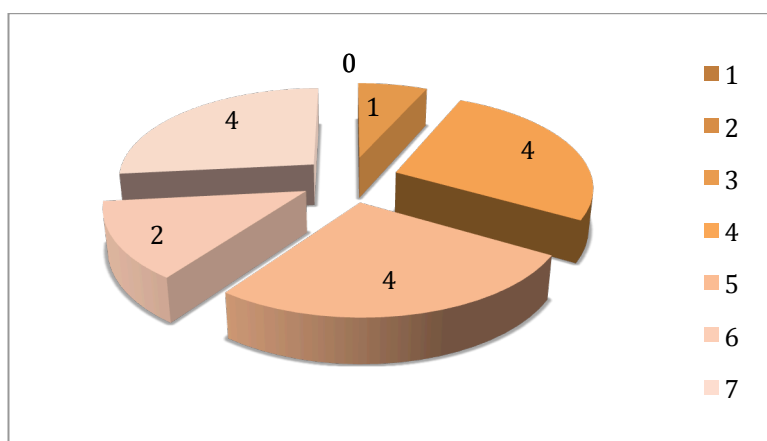
3. How natural did your interactions with the environment seem? 1= not at all; 7 = extremely



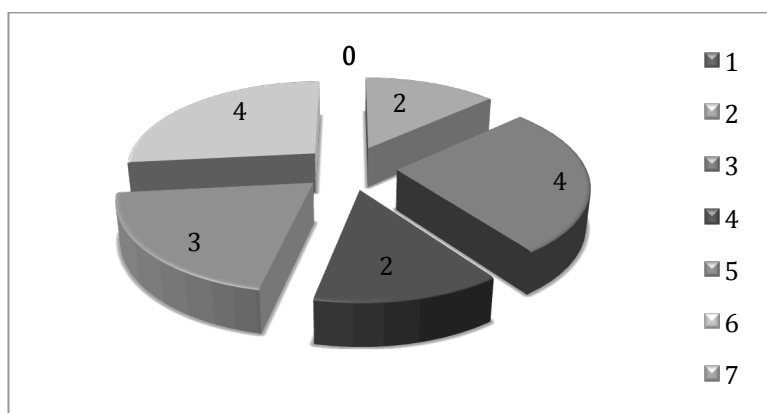
4. How completely were all of your senses engaged?
1= not at all; 7 = extremely



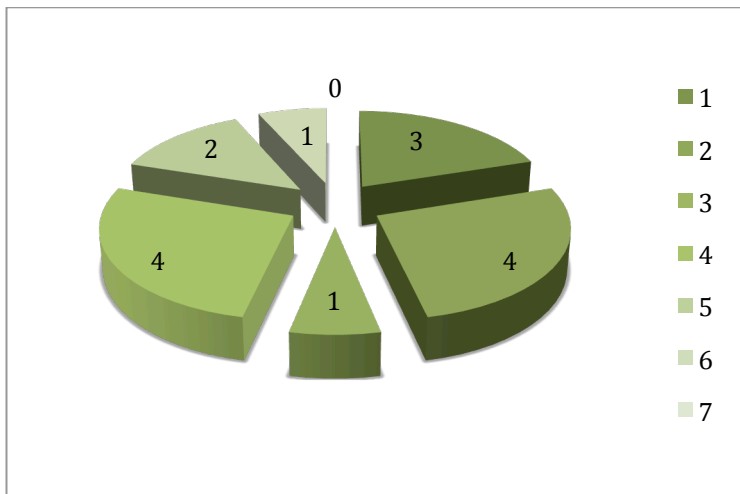
5. How much did the visual aspect of the installation involve you?
1= not at all; 7 = extremely



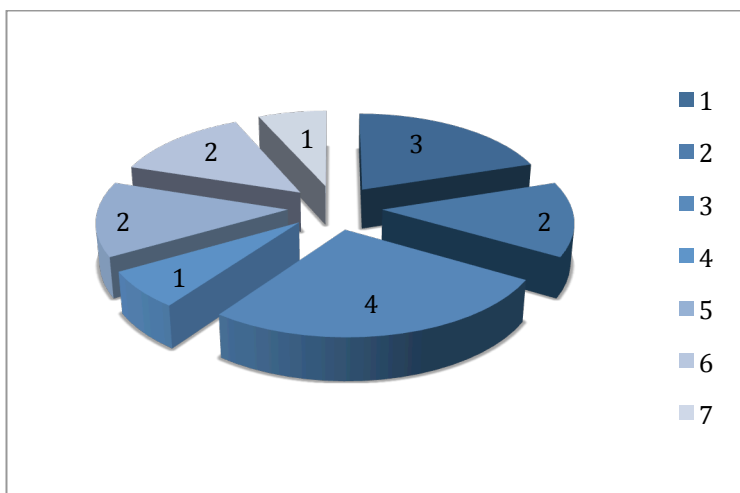
6. How natural was the mechanism, which controlled movement through the environment? 1= not at all; 7 = extremely



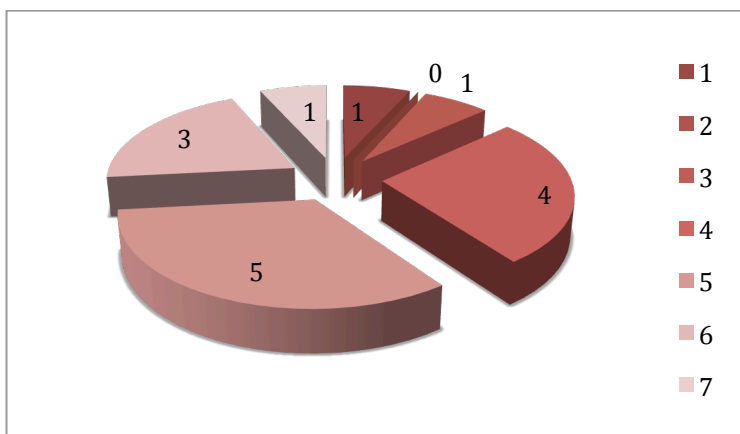
7. How aware were you of events that occurred around you?
1= not at all; 7 = extremely



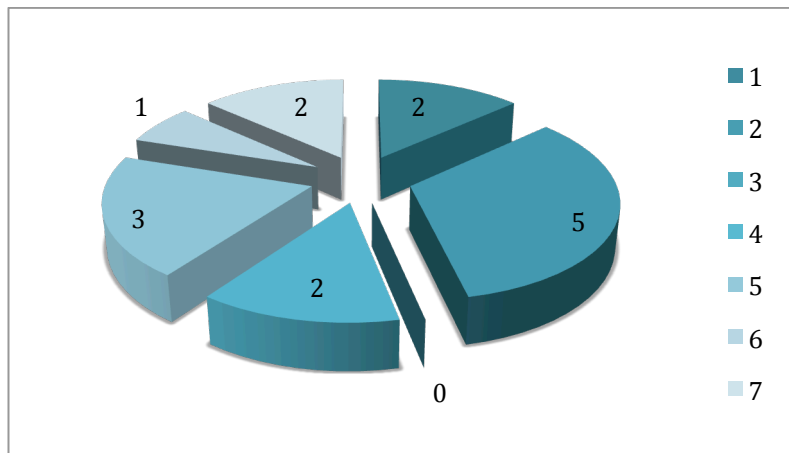
8. How aware were you of your display and control devices?
1= not at all; 7 = extremely



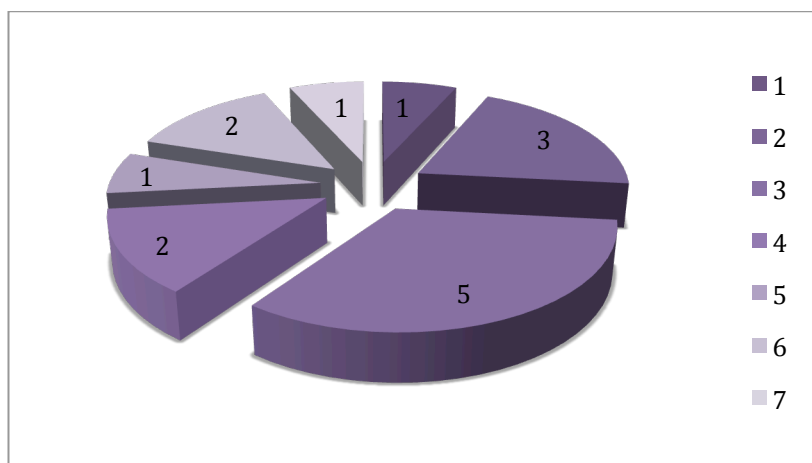
9. How compelling was your sense of objects in space?
1= not at all; 7 = extremely



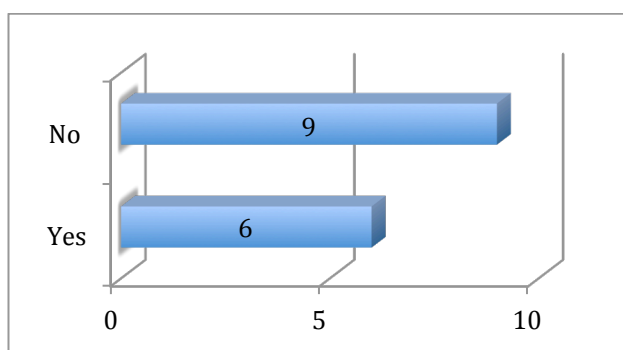
10. How inconsistent or disconnected was the information coming from various senses? 1= not at all; 7 = extremely



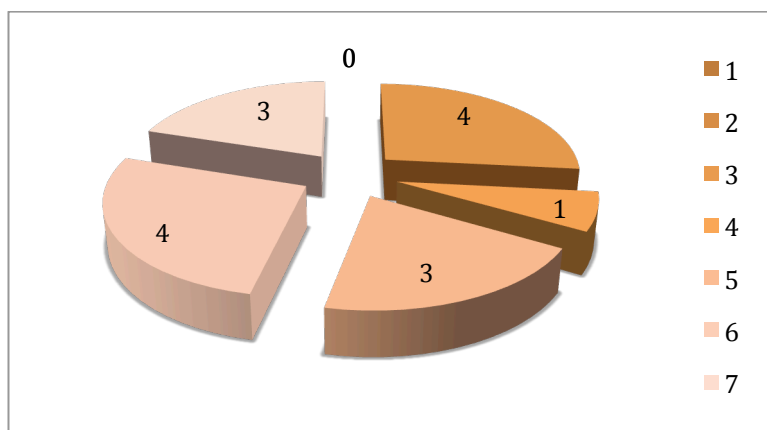
11. How much did your experience in the virtual environment seem consistent with your real world experience? 1= not at all; 7 = extremely



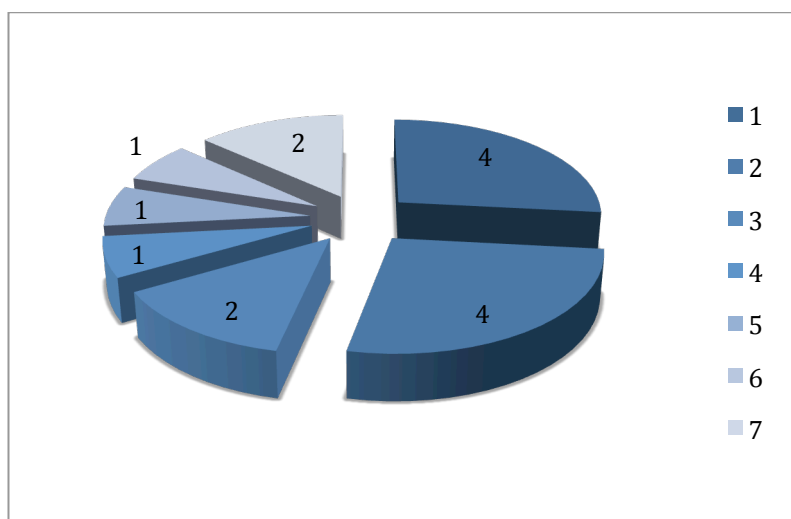
12. Were you able to anticipate what would happen next in response to the actions you performed?



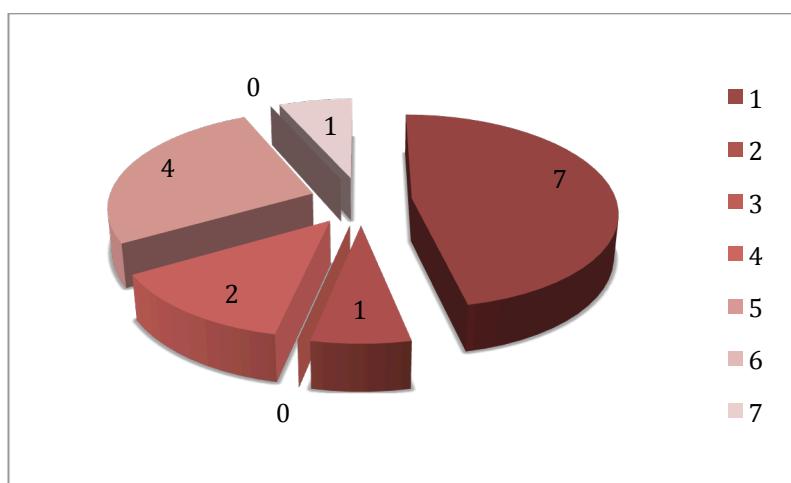
13. How completely were you able to actively survey the experience using vision? 1= not at all; 7=completely



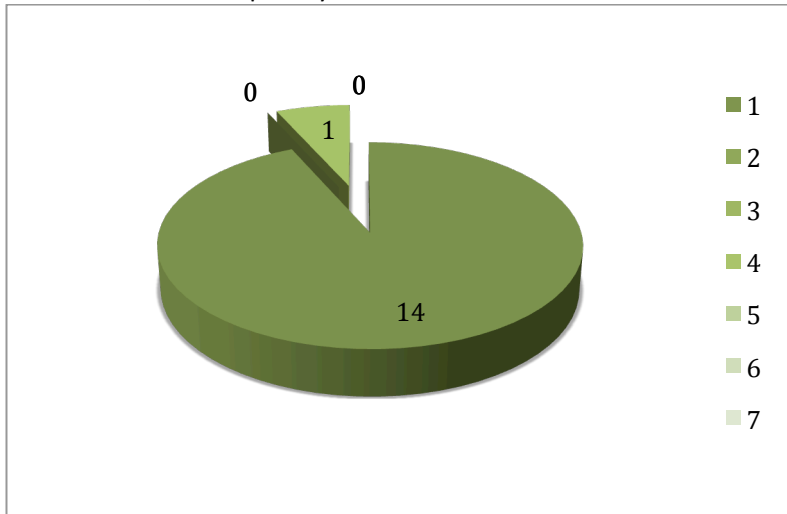
14. How well could you identify sounds? 1= not at all; 7=completely



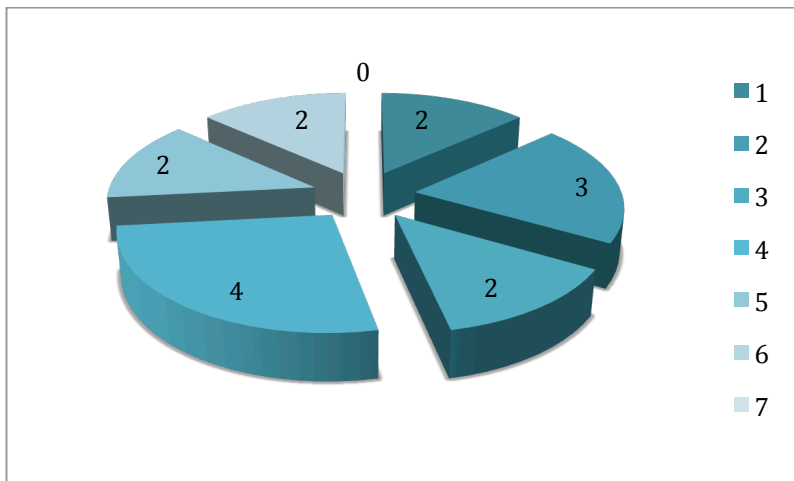
15. How well could you localise sounds? 1= not at all; 7= completely



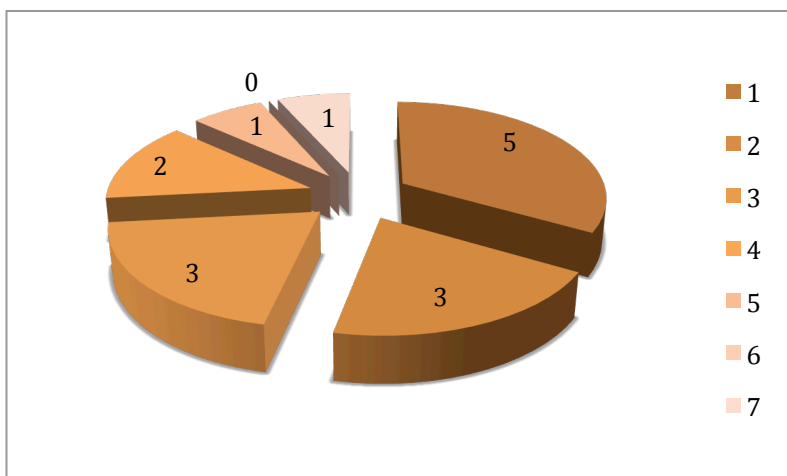
16. How well could you actively survey the virtual environment using touch?
1= not at all; 7= completely



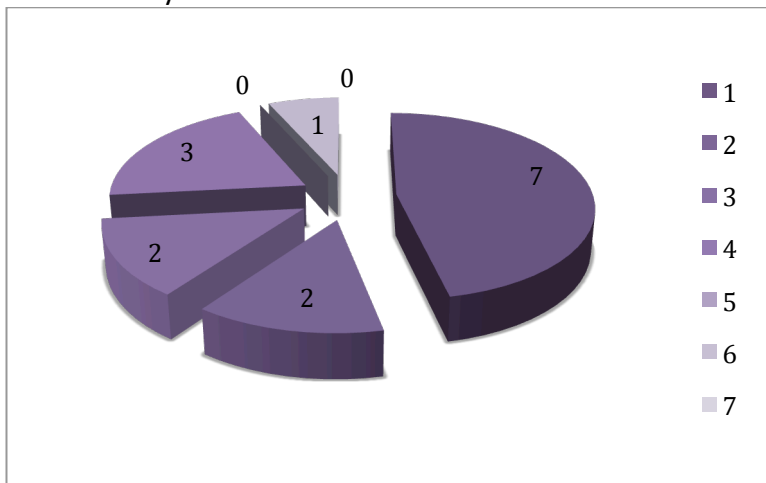
17. How compelling was your sense of moving around inside the environment?
1= not at all; 7= extremely



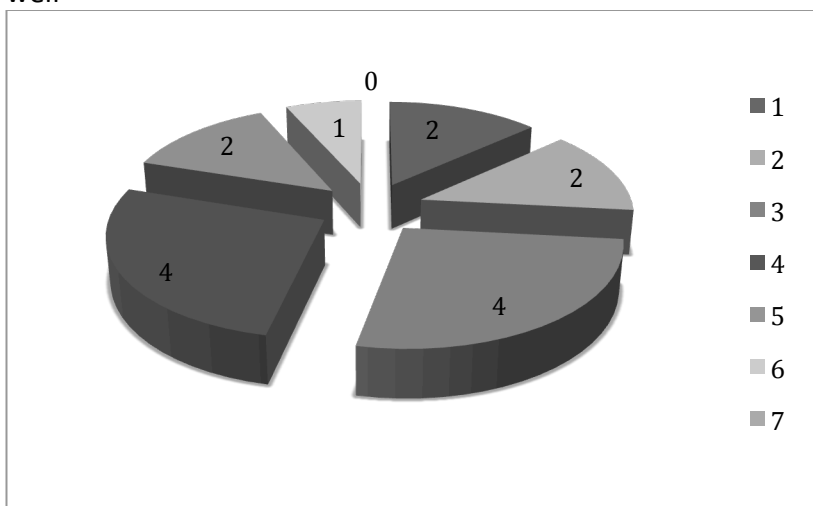
18. How closely were you able to examine objects? 1= not at all; 7= extremely



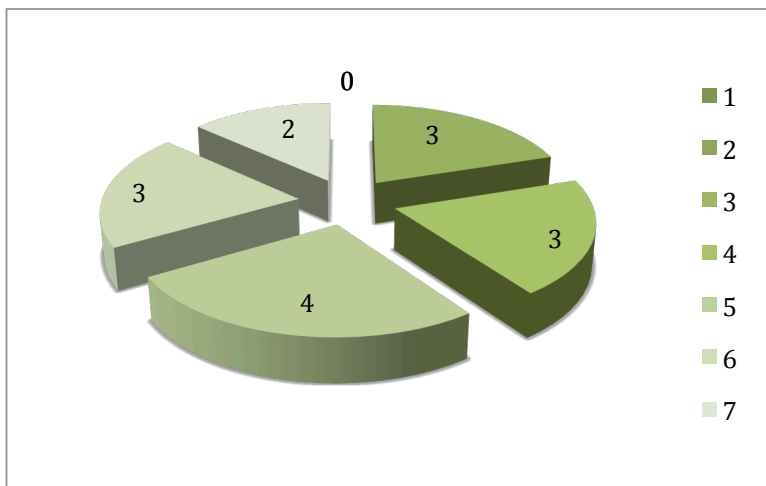
19. How well could you examine objects from different viewpoints? 1= not at all; 7= extremely



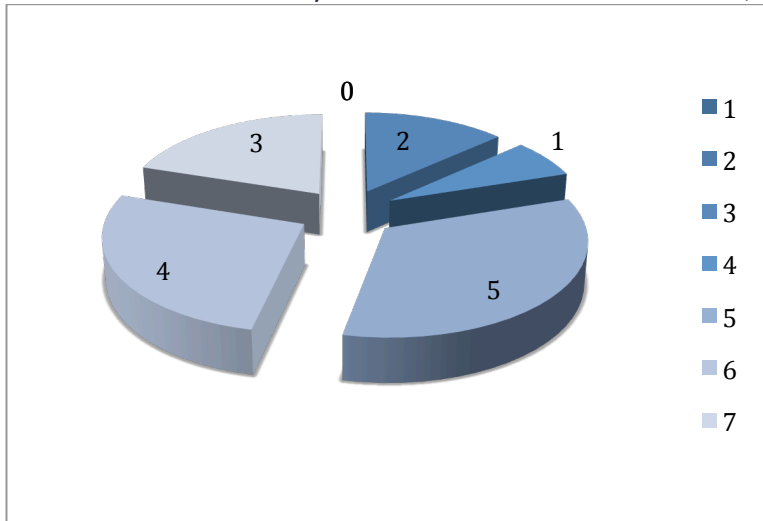
20. How well could you move or manipulate objects? 1= not at all; 7= extremely well



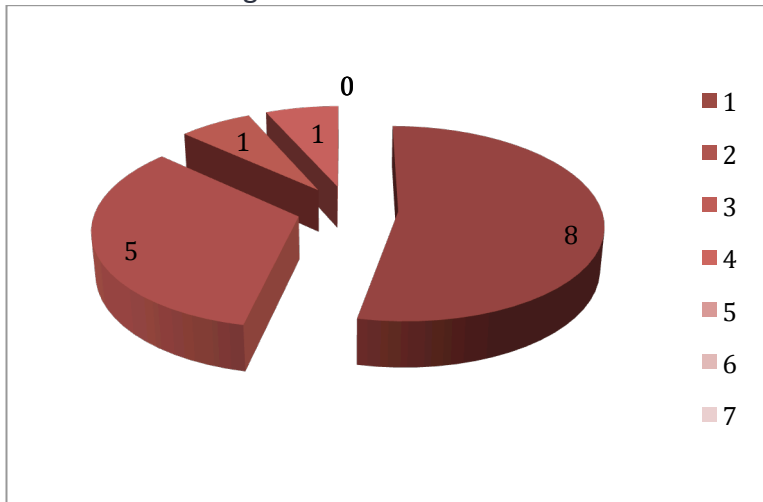
21. To what degree did you feel confused? 1= not at all; 7= extremely



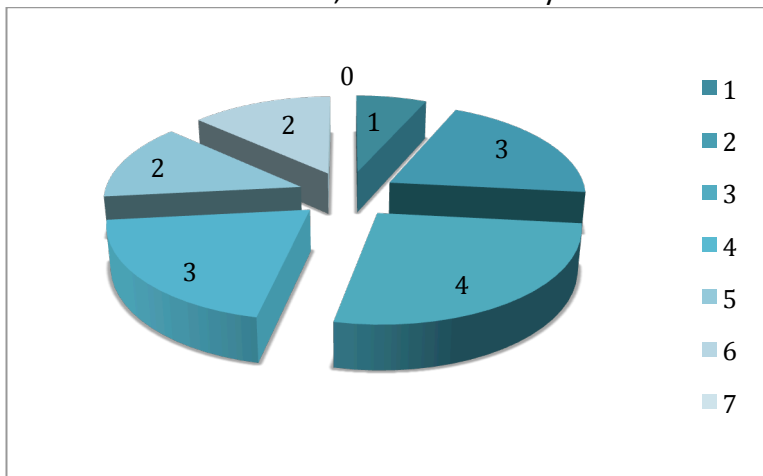
22. How involved were you in Transmission? 1= not at all; 7= extremely



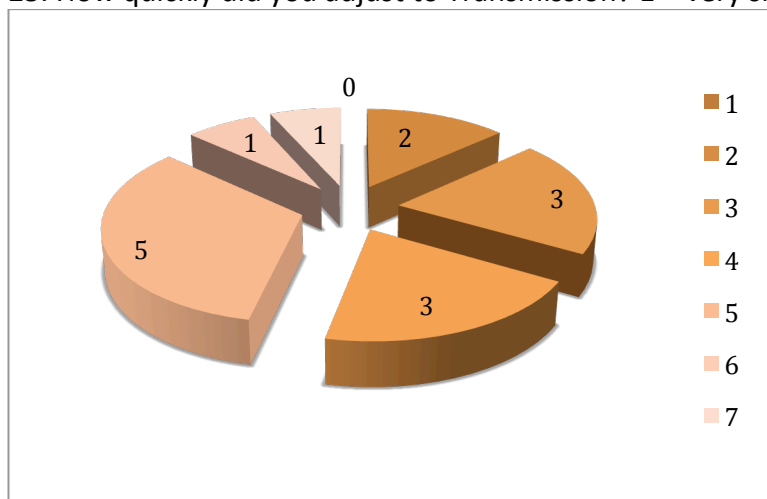
23. How distracting was the control mechanism? 1= not at all; 7= extremely



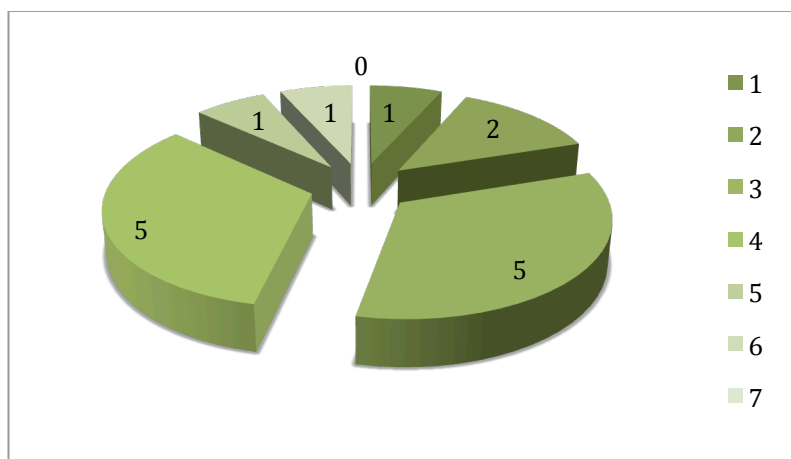
24. How much delay did you experience between your actions and expected outcomes? 1= none at all; 7= a lot of delay



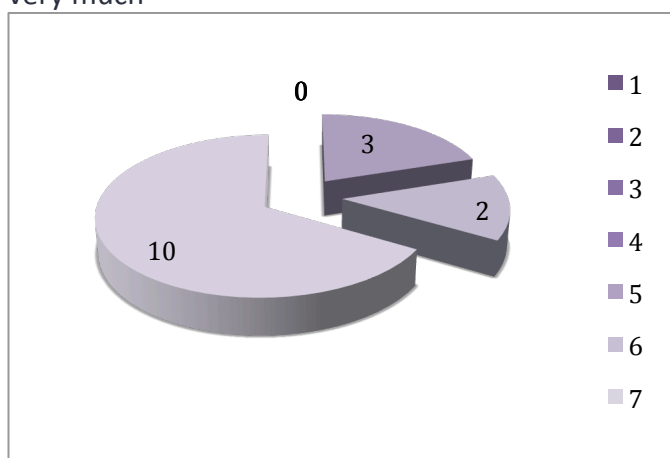
25. How quickly did you adjust to Transmission? 1 = very slowly; 7= very quickly



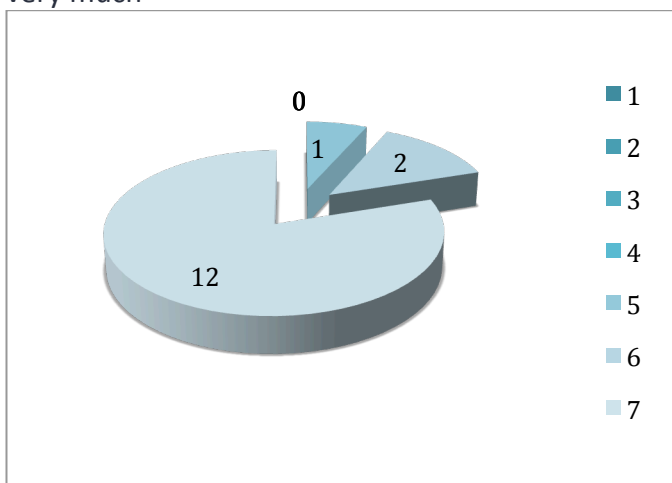
26. How proficient in interacting with Transmission did you feel at the end of your experience? 1= Not at all; 7 = very proficient



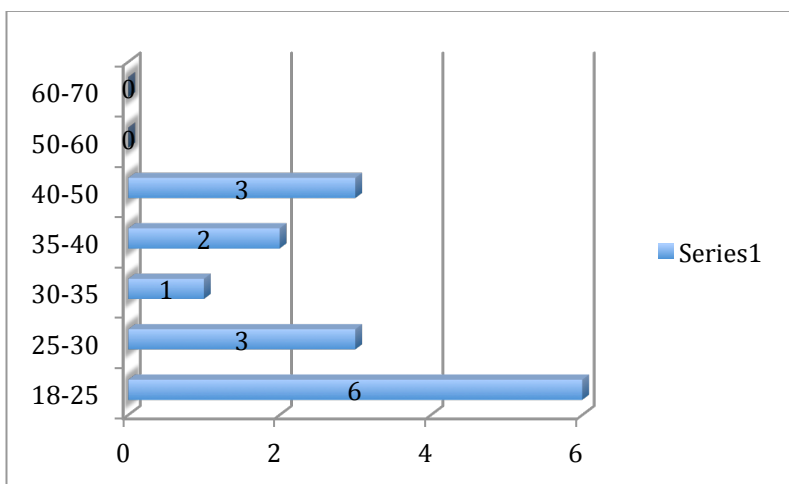
27. Would you like to see Transmission as a performance? 1= not very much; 7= very much



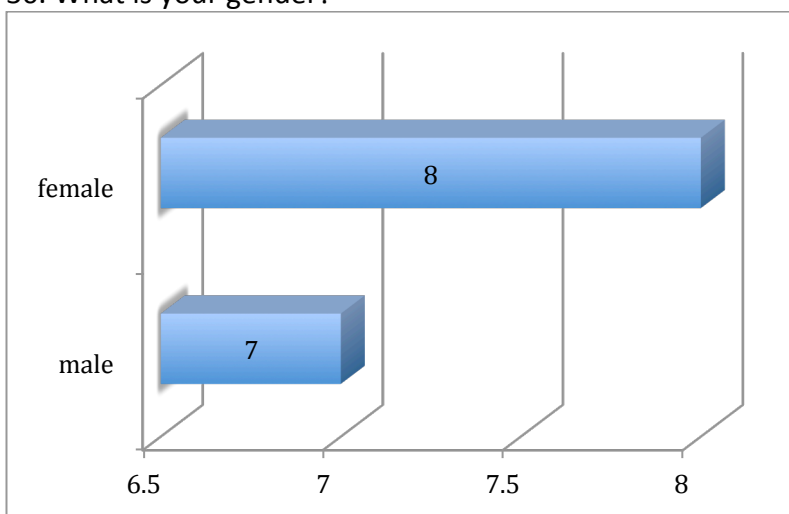
28. Would you like to see Transmission in other contexts? 1= not very much; 7= very much



29. How old are you?



30. What is your gender?



12.9 Method Overview

Case Study I - Immersion: KIMA

Research Question:

Does Immersive Sound Affect the Perception of Presence?

Method: Focus Group / Survey / Presence Questionnaire / Observation

Hypothesis:

N1: Surround sound influences the perception of remote presence through increased immersion.

N0: Surround sound does not positively affect the perception of presence in a remote location.

Independent variable (immersion) dependent variable (presence), control variables (inclusion, extensive cues, surrounding cues, vivid cues) social cues, attention, temporal cues.

Sample: 10-15 Media Arts Experts

Baseline: 2D sound at start of the experiment

Control Group: 2D sound

Independent Variable: Immersion

Dependent Variable: Presence Experience (measured through questionnaires and interviews)

Confounding Variable: Latency

mix methods, sequential study:

Phase 1 - Exploratory - Arts Council Screening

-) Survey / Questionnaire
-) Focus Group (organise transcript)

Phase 2 - explanatory - Festival of Learning

-) Presence Questionnaire
-) Field Study / Observation
- Evaluation Factors: inclusive, extensive, surrounding, vivid cues - social cues, attention, temporal cues.

Case Study II - Interactivity: Transmission

Research Question:

How does interactivity influence the perception of presence?

Methods: Experiment / Interviews / Observation

N1: Interactivity positively influences the perception of presence through dimensionality of communication, temporal cues, active control.

N0: Increased interactivity does not influence the perception of presence.

Sample: 20-30 Students

Setting: at BU beginning of February

Baseline: Recording of people experiencing their own brainwave visualisation

Control Group: Recorded interactivity

Independent Variable: Interactivity

Dependent Variable: Brainwave data

Mediating Variable: control, dimensionality, temporal

Pilot Study in January

Mixed methods, sequential study

Exploratory:

Experiment - Establishing causal relationship

Measuring Engagement and excitement levels through EEG, baseline figure through non-interactive mode; control group (non interactive)

Explanatory:

Questionnaires / Interviews - Evaluating Key Factors - communication, temporal cues, active control.

Case Study III - Realism: Aura

Research Question

How does realism contribute to the perception of remote presence?

Method: Matter Analysis /Focus Group / Expert Interviews

N1: Realism conveyed through specific audiovisual cues and production standards positively influences remote presence experiences.

N0: Realism does not influence remote presence experiences:

Sample: 10-15 Media Arts Experts

Baseline recording: People looking at an alter ego in real-time

Control Group: Realistic images

Independent Variable: Brain-activity (NFB)

Dependent Variable: Behaviour (PQ)

mixed methods, sequential study

Step 1 Exploratory:

Experiment: Compare presence through abstract shapes to realistic depiction

Control group: realistic or non-realistic? Baseline?

Control Group: Abstract shapes created through EEGs

- Expert Interviews (Polycom test)
- Comparative Quasi-Experiment

Meta- analysis (statistic importance)

Balance parameters / Cochran group style

Focus Groups: Expert Interview (Test setup) / Statements

Conclusion "transcription" Graphical: horizontal bar graph =

Participant Observation: Discrete units of analysis

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Transmission Tabulated Results

Category	Regional Performance										Global Performance										Operational Metrics									
	North America	South America	Europe	Asia Pacific	Africa	Oceania	Latin America	Europe	Asia Pacific	Africa	Latin America	North America	South America	Europe	Asia Pacific	Africa	Latin America	Production Volume	Quality Score	Delivery Time	Customer Satisfaction	Employee Engagement	Compliance Score							
Manufacturing Division	120,000	80,000	150,000	200,000	50,000	30,000	100,000	180,000	220,000	60,000	40,000	110,000	190,000	230,000	70,000	50,000	120,000	1,500,000	95%	24h	4.8/5	85%	98%							
	90,000	60,000	110,000	150,000	40,000	20,000	80,000	140,000	180,000	50,000	30,000	90,000	160,000	200,000	60,000	40,000	100,000	1,200,000	92%	36h	4.5/5	80%	95%							
	110,000	70,000	130,000	180,000	55,000	35,000	105,000	170,000	210,000	65,000	45,000	115,000	195,000	235,000	75,000	55,000	125,000	1,400,000	96%	20h	4.9/5	88%	99%							
	85,000	55,000	105,000	140,000	35,000	15,000	75,000	130,000	170,000	45,000	25,000	85,000	150,000	190,000	55,000	35,000	95,000	1,100,000	90%	48h	4.3/5	75%	92%							
	100,000	65,000	120,000	160,000	50,000	30,000	90,000	160,000	200,000	60,000	40,000	100,000	180,000	220,000	70,000	50,000	110,000	1,300,000	94%	30h	4.6/5	82%	96%							
Sales & Marketing	95,000	60,000	115,000	155,000	45,000	25,000	85,000	145,000	185,000	55,000	35,000	95,000	165,000	205,000	65,000	45,000	105,000	1,250,000	93%	33h	4.4/5	78%	94%							
	105,000	75,000	125,000	170,000	55,000	35,000	105,000	175,000	215,000	65,000	45,000	115,000	195,000	235,000	75,000	55,000	125,000	1,450,000	97%	22h	4.9/5	89%	99%							
	80,000	50,000	100,000	130,000	30,000	10,000	70,000	120,000	160,000	40,000	20,000	80,000	140,000	180,000	50,000	30,000	90,000	1,000,000	88%	54h	4.2/5	70%	90%							
	115,000	70,000	135,000	185,000	55,000	35,000	105,000	175,000	215,000	65,000	45,000	115,000	195,000	235,000	75,000	55,000	125,000	1,400,000	96%	20h	4.9/5	88%	99%							
	90,000	60,000	110,000	150,000	40,000	20,000	80,000	140,000	180,000	50,000	30,000	90,000	160,000	200,000	60,000	40,000	100,000	1,200,000	92%	36h	4.5/5	80%	95%							
Logistics & Distribution	100,000	65,000	120,000	160,000	50,000	30,000	90,000	160,000	200,000	60,000	40,000	100,000	180,000	220,000	70,000	50,000	110,000	1,300,000	94%	30h	4.6/5	82%	96%							
	95,000	60,000	115,000	155,000	45,000	25,000	85,000	145,000	185,000	55,000	35,000	95,000	165,000	205,000	65,000	45,000	105,000	1,250,000	93%	33h	4.4/5	78%	94%							
	105,000	75,000	125,000	170,000	55,000	35,000	105,000	175,000	215,000	65,000	45,000	115,000	195,000	235,000	75,000	55,000	125,000	1,450,000	97%	22h	4.9/5	89%	99%							
	80,000	50,000	100,000	130,000	30,000	10,000	70,000	120,000	160,000	40,000	20,000	80,000	140,000	180,000	50,000	30,000	90,000	1,000,000	88%	54h	4.2/5	70%	90%							
	115,000	70,000	135,000	185,000	55,000	35,000	105,000	175,000	215,000	65,000	45,000	115,000	195,000	235,000	75,000	55,000	125,000	1,400,000	96%	20h	4.9/5	88%	99%							
Customer Support	90,000	60,000	110,000	150,000	40,000	20,000	80,000	140,000	180,000	50,000	30,000	90,000	160,000	200,000	60,000	40,000	100,000	1,200,000	92%	36h	4.5/5	80%	95%							
	100,000	65,000	120,000	160,000	50,000	30,000	90,000	160,000	200,000	60,000	40,000	100,000	180,000	220,000	70,000	50,000	110,000	1,300,000	94%	30h	4.6/5	82%	96%							
	95,000	60,000	115,000	155,000	45,000	25,000	85,000	145,000	185,000	55,000	35,000	95,000	165,000	205,000	65,000	45,000	105,000	1,250,000	93%	33h	4.4/5	78%	94%							
	105,000	75,000	125,000	170,000	55,000	35,000	105,000	175,000	215,000	65,000	45,000	115,000	195,000	235,000	75,000	55,000	125,000	1,450,000	97%	22h	4.9/5	89%	99%							
	80,000	50,000	100,000	130,000	30,000	10,000	70,000	120,000	160,000	40,000	20,000	80,000	140,000	180,000	50,000	30,000	90,000	1,000,000	88%	54h	4.2/5	70%	90%							
Human Resources	110,000	70,000	130,000	180,000	55,000	35,000	105,000	170,000	210,000	65,000	45,000	115,000	195,000	235,000	75,000	55,000	125,000	1,400,000	96%	20h	4.9/5	88%	99%							
	90,000	60,000	110,000	150,000	40,000	20,000	80,000	140,000	180,000	50,000	30,000	90,000	160,000	200,000	60,000	40,000	100,000	1,200,000	92%	36h	4.5/5	80%	95%							
	100,000	65,000	120,000	160,000	50,000	30,000	90,000	160,000	200,000	60,000	40,000	100,000	180,000	220,000	70,000	50,000	110,000	1,300,000	94%	30h	4.6/5	82%	96%							
	95,000	60,000	115,000	155,000	45,000	25,000	85,000	145,000	185,000	55,000	35,000	95,000	165,000	205,000	65,000	45,000	105,000	1,250,000	93%	33h	4.4/5	78%	94%							
	105,000	75,000	125,000	170,000	55,000	35,000	105,000	175,000	215,000	65,000	45,000	115,000	195,000	235,000	75,000	55,000	125,000	1,450,000	97%	22h	4.9/5	89%	99%							
Finance & Accounting	80,000	50,000	100,000	130,000	30,000	10,000	70,000	120,000	160,000	40,000	20,000	80,000	140,000	180,000	50,000	30,000	90,000	1,000,000	88%	54h	4.2/5	70%	90%							
	115,000	70,000	135,000	185,000	55,000	35,000	105,000	175,000	215,000	65,000	45,000	115,000	195,000	235,000	75,000	55,000	125,000	1,400,000	96%	20h	4.9/5	88%	99%							
	90,000	60,000	110,000	150,000	40,000	20,000	80,000	140,000	180,000	50,000	30,000	90,000	160,000	200,000	60,000	40,000	100,000	1,200,000	92%	36h	4.5/5	80%	95%							
	100,000	65,000	120,000	160,000	50,000	30,000	90,000	160,000	200,000	60,000	40,000	100,000	180,000	220,000	70,000	50,000	110,000	1,300,000	94%	30h	4.6/5	82%	96%							
	95,000	60,000	115,000	155,000	45,000	25,000	85,000	145,000	185,000	55,000	35,000	95,000	165,000	205,000	65,000	45,000	105,000	1,250,000	93%	33h	4.4/5	78%	94%							
IT & Technology	105,000	75,000	125,000	170,000	55,000	35,000	105,000	175,000	215,000	65,000	45,000	115,000	195,000	235,000	75,000	55,000	125,000	1,450,000	97%	22h	4.9/5	89%	99%							
	80,000	50,000	100,000	130,000	30,000	10,000	70,000	120,000	160,000	40,000	20,000	80,000	140,000	180,000	50,000	30,000	90,000	1,000,000	88%	54h	4.2/5	70%	90%							
	115,000	70,000	135,000	185,000	55,000	35,000	105,000	175,000	215,000	65,000	45,000	115,000	195,000	235,000	75,000	55,000	125,000	1,400,000	96%	20h	4.9/5	88%	99%							
	90,000	60,000	110,000	150,000	40,000	20,000	80,000	140,000	180,000	50,000	30,000	90,000	160,000	200,000	60,000	40,000	100,000	1,200,000	92%	36h	4.5/5	80%	95%							
	100,000	65,000	120,000	160,000	50,000	30,000	90,000	160,000	200,000	60,000	40,000	100,000	180,000	220,000	70,000	50,000	110,000	1,300,000	94%	30h	4.6/5	82%	96%							
Legal & Compliance	95,000	60,000	115,000	155,000	45,000	25,000	85,000	145,000	185,000	55,000	35,000	95,000	165,000	205,000	65,000	45,000	105,000	1,250,000	93%	33h	4.4/5	78%	94%							
	105,000	75,000	125,000	170,000	55,000	35,000	105,000	175,000	215,000	65,000	45,000	115,000	195,000	235,000	75,000	55,000	125,000	1,450,000	97%	22h	4.9/5	89%	99%							
	80,000	50,000	100,000	130,000	30,000	10,000	70,000	120,000	160,000	40,000	20,000	80,000	140,000	180,000	50,000	30,000	90,000	1,000,000	88%	54h	4.2/5	70%	90%							
	115,000	70,000	135,000	185,000	55,000	35,000	105,000	175,000	215,000	65,000	45,000	115,000	195,000	235,000	75,000	55,000	125,000	1,400,000	96%	20h	4.9/5	88%	99%							
	90,000	60,000	110,000	150,000	40,000	20,000	80,000	140,000	180,000	50,000	30,000	90,000	160,000	200,000	60,000	40,000	100,000	1,200,000	92%	36h	4.5/5	80%	95%							
Overall Company	120,000	80,000	150,000	200,000	50,000	30,000	100,000	180,000	220,000	60,000	40,000	110,000	190,000	230,000	70,000	50,000	120,000	1,500,000	95%	24h	4.8/5	85%	98%							
	90,000	60,000	110,000	150,000	40,000	20,000	80,000	140,000	180,000	50,000	30,000	90,000	160,000	200,000	60,000	40,000	100,000	1,200,000	92%	36h	4.5/5	80%	95%							
	110,000	70,000	130,000	180,000	55,000	35,000	105,000	170,000	210,000	65,000	45,000	115,000	195,000	235,000	75,000	55,000	125,000	1,400,000	96%	20h	4.9/5	88%	99%							
	85,000	55,000	105,000	140,000	35,000	15,000	75,000	130,000	170,000	45,000	25,000	85,000	150,000	190,000	55,000	35,000	95,000	1,100,000	90%	48h	4.3/5	75%	92%							
	100,000	65,000	120,000	160,000	50,000	30,000	90,000	160,000	200,000	60,000	40,000	100,000	180,000	220,000	70,000	50,000	110,000	1,300,000	94%	30h	4.6/5	82%	96%							

[illegible]

12.11 Transmission Statistic Data EEG – Tabulated

Transmission Tabulated Results - EEG

User 2	User 2 Post	User 3	User 3 after	User 4	User 4 After	User 5	User 5 After	User 6	User 6 after	User 7	User 7 after
10.92154	12.3088975	9.04	24.8272996	1.598261	21.3218776	6.70652	9.7589146	15.9843367	22.31731621	12.778	14.5615553
9.603846	37.70625	49.6	68.6372054	21.77698	12.74437444	28.2796	30.469113	19.9544598	33.15778894	9.8336	40.698364

User 8	User 8 after	User 9	User 9 after	User 11	User 11 after	User 12	User after 12	User 13	User 13 after
17.5256	12.159586	17.1	9.53154321	16.96977	10.235942	11.7089759	11.96712471	10.8539852	5.001938
48.762	31.484206	41.4	31.5523724	26.44175	29.94354	36.0451002	31.71284301	30.752451	26.7323119

Aura - Statistic Meta Analysis

[illegible]

12.13 Aura Meta Analysis – Initial Catalogue

	Authors	Measuring	Cited	Method	Reliability	Validity	Sensitivity
Hendrix & Barfield (1996)	Barfield & Weghorst (1993)	Monoscopic vs Stereoscopic displays Field of View 10/50/90 degrees Head/Tracking	Barfield, W., & Weghorst, S. (1993). The sense of presence within virtual environments: A conceptual framework. In G. Salvendy & M. Smith (Eds), <i>Human-computer interaction: Applications and case studies</i> (pp.699-704). Amsterdam: Elsevier.	Type: Questionnaire n=86 Between subject design n=12	<i>Reliability:</i> An intercorrelation was found between the three items, and there was consistency across items and studies.	<i>Validity:</i> There was a correlation with realism and other related constructs, and the effects of the manipulation of variables (stereoscopy, head tracking, field of view) on the scores are as predicted by theory and previous findings in presence research.	<i>Sensitivity:</i> The questionnaire discriminated between different conditions.
Cho et al.	Cho, D., Park, J., Kim, G., Hong, S., Han, S., & Lee, S. (2003). Dichotomy of presence elements: The where and what. <i>Proceedings of the IEEE Virtual Reality 2003</i> , 273-274.	<i>Concept:</i> Physical presence. The questionnaire consists of 4 items relating to the: 1. Visual realism of objects 2. Ability to perceive locations of oneself and other objects 3. Visual realism of the overall environment 4. Feeling of being in the environment The exact wording of items is not reported in the paper. Items are rated on a 0-100 scale.			<i>Reliability:</i> Not reported.	<i>Validity:</i> The experimental results obtained with the questionnaire supported the authors' theory of presence.	<i>Sensitivity:</i> Not reported.
IGROUP PRESENCE QUESTIONNAIRE (IPQ)	Schubert, Friedmann, & Regenbrecht (2000) have argued that presence develops from the construction of a spatial-functional mental model of the VE. Two cognitive processes contribute to this model: construction, or the representation of bodily actions as possible actions in the VE, and suppression of incompatible sensory input.	To construct the first version of the IPQ, 75 items from previously published questionnaires (including Witmer & Singer, Hendrix, Slater-Usch-Steed), items from the authors' own past research and newly designed items were combined into one questionnaire. The final version of the IPQ consists of 14 items rated on a five point rating scale.	Schubert, T., Friedmann, F., & Regenbrecht, H. (2001). The experience of presence: Factor analytic insights. <i>Presence: Teleoperators and Virtual Environments</i> , 10, 266-281.		<i>Reliability:</i> Internal consistency, $\alpha=.87$	<i>Validity:</i> Data gathered with the questionnaire yielded a similar factor structure as was found in other studies.	<i>Sensitivity:</i> Not reported.

KIM & BIOCCA QUESTIONNAIRE	The questionnaire was developed in the context of a study (n=96, between-subjects design) investigating the effects of telepresence in a television viewing situation on memory and persuasion. Unmediated visual stimuli (active or suppressed) and viewing angle (low, medium, or high) were manipulated.	Exploratory factor analyses revealed that the eight items could be grouped into two factors, which were labelled "departure" and "arrival". The manipulation of unmediated visual stimuli and viewing angle did not have an effect on either departure or arrival.	Kim, T., & Biocca, F. (1997). Telepresence via television: Two dimensions of telepresence may have different connections to memory and persuasion. <i>Journal of Computer-Mediated Communication</i> , 3 (2).		<i>Reliability:</i> Not reported	<i>Validity:</i> Manipulations that were hypothesized to influence presence did not have an effect on the questionnaire scores.	<i>Sensitivity:</i> Not reported.
PQ	Witmer and Singer (1998) identified involvement and immersion as conditions for presence. They aimed to develop a measure of presence addressing factors that influence involvement and immersion. Main categories of such factors were derived from the work of Sheridan (1992) and Held & Durlach (1992):	- Control factors (degree, immediacy, anticipation, mode, and physical environment modifiability)	- Sensory factors (modality, environmental richness, multimodal presentation, consistency of multimodal information, the degree of movement perception, and active search)	- Realism factors (scene realism, information consistent with the objective world, meaningfulness of the experience, separation, and anxiety/disorientation).	Baños, R. M., Botella, C., Garcia-Palacios, A., Villa, H., Perpina, C., & Alcaniz, M. (2000). Presence and reality judgment in virtual environments: A unitary construct? <i>CyberPsychology and Behaviour</i> , 3, 327-		
REALITY JUDGMENT AND PRESENCE QUESTIONNAIRE	The final version (derived from the long version containing 77 items) of the Reality Judgment and Presence Questionnaire contains 18 items in three dimensions:	1. Reality Judgment 2. Internal/External Correspondence 3. Absorption / Attention	Items are scored on a ten point rating scale. Both the 77 original items and the items retained after the factor analysis are listed in Appendix A.		<i>Reliability:</i> Internal consistency $\alpha = .82$.	<i>Validity:</i> Not reported.	<i>Sensitivity :</i> Not reported.
SLATER-USOH-STEED QUESTIONNAIRE (SUS)		1. Sense of being there 2. Extent to which the VE becomes more "real or present" than reality 3. Locality: the extent to which the VE is thought of as a place visited.	Slater, M., Usoh, M., & Steed, A. (1994). Depth of presence in virtual environments. <i>Presence: Teleoperators and Virtual Environments</i> , 3, 130-144.	Usoh, M., Arthur, K., Whitton, M. C., Bastos, R., Steed, A., Slater, M., et al. (1999). Walking > walking-in-Place > flying in virtual environments. <i>Computer Graphics, Annual Conference Series: Proceedings of SIGGRAPH 1999</i> , 359-364.	The original SUS questionnaire score is calculated as the number of high (score six or seven) responses. This avoids the problem of averaging ordinal responses, and allows the use of logistic regression.		

BAIENSON ET AL.	The questionnaire was used in an experiment investigating personal space. Participants (n=50, within-subjects design) were immersed in a virtual room in which a virtual male agent stood. In each trial they were asked to walk up to the agent and remember certain features and labels on the front and back of the agent's shirt. The position and orientation of participants were tracked.	The photographic realism of the agent's face and the degree of mutual gaze between agent and participant were varied. After the experience was over, participants once more put on the HMD to rate the two different avatar types for social presence. A Likert-type scale (-3 to +3) was shown over the agent's head. Participants looked at the agent and the scale while the experimenter read out the questions. Internal consistency was $\alpha=.83$. For women, a significant correlation was found between degree of gaze and social presence, but not for men. No effect of realism was found. The same pattern of results was found for interpersonal distance	Bailenson, J.N., Blascovich, J., Beall, A.C., & Loomis, J.M. (2001). Equilibrium revisited: Mutual gaze and personal space in virtual environments. <i>Presence: Teleoperators and Virtual Environments</i> , 10, 583-598.	All participants maintained more space around agents than they did around similarly sized and shaped but nonhuman-like objects. Female participants maintained more interpersonal distance between themselves and agents who engaged them in eye contact (that is, mutual gaze behavior) than between themselves and agents who did not engage them in eye contact, whereas male participants did not.	<i>Reliability:</i> Internal consistency $\alpha=.83$.	<i>Validity:</i> The results obtained with the questionnaire were similar to an interpersonal distance measure. The correlation between the measures is not reported.	<i>Sensitivity:</i> Questionnaire scores discriminated between different conditions (degrees of gaze).
Edges	Vicki Bruce, Patrick Green, and Mark Georgeson.	University of Est Sussex	Visual Perception: Physiology, Psychology, and Ecology. UK, 1996. Psychology Press.				
Reflections	Alan Gilchrist. Lawrence Erlbaum.	Hillsdale, NJ, 1994.	Lightness, Brightness and Transparency. Hillsdale, NJ, 1994. Lawrence Erlbaum.				
Natural Images, Spatial Frequency	Babubhai Shah, Beth Barnwell, and Gayle Bieler.		SUDAAN User's Manual, Release 7. Research Triangle Institute, Research Triangle Park, NC. 1999. Research Triangle Institute Press				
threshold visibility, color appearance, visual acuity, and changes in visual sensitivity over time	James A. Ferwerda Sumanta N. Pattanaik Peter Shirley Donald P. Greenberg	Program for Computer Graphics at Cornell University	A Model of Visual Adaptation for Realistic Image Synthesis	Development of a model for visual adaptation for realistic image synthesis based on psychophysical experiments.	Model is based on scientific findings on acuity, light sensitivity of rods and cones, Shaler's experiment of 1937, Adelson's experiment		

					on adaptation of rods from 1982 and Bakers experiment from 1949 on cone adaptation. And experiments on the relationship between the two by Riggs 1971 called "The Purkinje break". These findings were correlated with Ward's and Rushmeiers threshold of visibility function to arrive at a computational model that takes the HVS into account.		
Sinusoidal gratings at different frequencies	Daly, Scott		The Visible Differences Predictor: An Algorithm for the Assessment of Image Fidelity. In: Digital Images and Human Vision, A. B. Watson, Ed., pp. 179-206. Cambridge, MA, 1993. MIT Press.				
Fidelity of Radiosity	Gary Meyer, Holly Rushmeier, Michael Cohen, Donald Greenberg, and Kenneth Torrance.	Cornell Box	An Experimental Evaluation of Computer Graphics Imagery. In Transactions on Graphics, 5 (1), pp. 30-50. New York, 1986. ACM.				
Fidelity of illumination	Ann McNamara, Alan Chalmers, Tom Troscianko, and Erik Reinhard.		Fidelity of Graphics Reconstructions: A Psychophysical Investigation. In Proceedings of the 9th Eurographics Rendering Workshop, pp. 237-246. June 1998. Springer Verlag.				
Ray Tracing	Glas, Andrew		An Introduction to Ray Tracing. New York, 1989. Academic Press.				
Radiosity	Cohen, Johnathan	Johns Hopkins Department of Computer Science					
Radiance	Ward, Gregory		The Radiance Lighting Simulation and Rendering System, Computer Graphics, Proceedings, Annual Conference Series, 1994, 28(4), ACM SIGGRAPH, pp 459-472.				

Global Illumination	Wald, I., Kollig, T., Benthin, C., Keller, A. Slusallek, P.	Interactive Global Illumination using Fast Ray Tracing	Thirteenth Eurographics Workshop on Rendering (2002)				
	Liu, a., tendick, f., cleary, k., and kaufmann, c. 2003. A survey of surgical simulation: Applications, technology, and education.	Presence-Teleoperators and Virtual Environments 12, 6, 599–614.					
First Pass Gaze	De Graef et al (1990)	Loftus & Mackworth	Friedman (1979)				
Scene viewing	Henderson, j. M. And ferreira, f. 2004.		Scene perception for psycholinguists. In The Interface of Language, Vision, and Action: Eyemovements and the Visual World, J. M. Henderson and F. F. Ferreira, Eds. Psychology Press, New York. 1–58.				
	Henderson, j. M. and Hollingworth, A., 1998.		Eye movements during scene viewing: An overview. In Eye guidance in Reading and Scene Perception, G. Underwood, Ed. Elsevier Science, Oxford.				
	Henderson, j. M. and Hollingworth, a.		High-level scene perception. Annu. Rev. Psychol. 50, 243–271.				
	Bertin, j. 1983. The Semiology of Graphics. University of Wisconsin Press, WA.						
	Bruce, vV, Green, P. R., and Georgeson, M. A. 1996. Visual Perception: Physiology, Psychology, and Ecology. Psychology Press,						
Acuity	Anstis, Stuart	Department of Psychology, University of California at San Diego, La Jolla, CA	Picturing Peripheral Acuity. Perception. 1998, volume 27, pages 817–825				
Density	Mackworth & Morandi 1967						

Information	Buswell and Yarbus	Mackworth & Morandi 1967	Antes1974				
Semantic Information	Loftus & Mackworth 1978	Buswell (1935) and Yarbus (1976)					
Perception vs Semantics	Binella, A., Mannan, S., & Ruddock, K.H. (1995)	Features: luminance maxima, luminance	Physics Department, Imperial College London	The characteristics of eye movements made during visual search with multi-element stimuli. Spatial Vision, 9, 343-362		Both the time $T_{1/2}$ taken to press a button to denote target detection (the manual response time) and the time T_f taken to fixate the target were determined. It is established that these two response times are closely related to each other, and have similar dependence on the number of reference elements N , both in search tasks for which $T_{1/2}$ is independent of N (parallel search) and in those for which $T_{1/2}$ is proportional to N (serial search).	
Quality of Speakers	Gabrielson, A., & Lindstrom, B. (1985). Perceived sound	Engineering Society, 33, 33-52.	Quality of high-fidelity loudspeakers. Journal of the Audio				
Brightness	McNamara, Chalmers, A., Troscianko, T., & Gilchrist, I.	Comparing real and synthetic scenes using human judgements of lightness.	In Proceedings of the Eurographics Workshop on Rendering Techniques. Springer-Verlag, New York. 207-218.2000.				
Inconsistency of subjective evaluation	Bertrand and Mullainathan 2000]	Post test evaluation problems Aldridge 1995].	Instructions: IJsselstein et al.2000; Freeman et al. 1999				
Perlin Noise	Perlin 1985	An image Synthesiser. Courant Institute of Mathematical Sciences New York University	An image Synthesiser. In: Siggraph 1985. Volume 19, Number 3, 1985	Algorithmic deduction.			
Detailed specular reflection	Mohamed elhelw, marios nicolaou, adrian chung, and guang-zhong yang	Imperial College London & M. STELLA ATKINS - Simon Fraser University	A Gaze-Based Study for Investigating the Perception of Visual Realism in Simulated Scenes				

Causality	Marc Cavazza* Jean-Luc Lugin, Marc Buehner	School of Computing University of Teesside Middlesbrough, TS1 3BA	Causal Perception in Virtual Reality and its Implications for Presence Factors	Witmer & Singer Questionnaire (9 Questions) Sample of 53 Subjects, including 2 control groups,	high construct validity, chi2 test, causality with high significance of 0.01 was established in ANOVA analysis; significant relationship between causality and presence and causality and realism p=0.001		
Colour/ Global Illumination	A. Gruson, M. Ribardi�re and R. Cozot	IRISA, Universit� de Rennes France	Eye-Centered Color Adaptation in Global Illumination	Visual Comparison of Raw images vsWilkie's method WCAM and adapted image - standard, complex and sequential visual tests	low construct validity		
Bidirectional Reflectance Distribution	Hanrahan, Pat & Krueger, Wolfgang	Department of Computer Science Princeton University; Department of Scientific Visualization German National Research Center for Computer Science	Components of reflected radiance: surface reflectance and subsurface volume scattering modulated by the Fresnel coefficients. Transport theory models describe this relationship. The change in radiance along a particular infinitesimal direction consists of two terms. The first term decreases the radiance due to absorption and scattering. The second term accounts for light scattered in the direction of ds from all other directions	"Components of reflected radiance: surface reflectance and subsurface volume scattering modulated by the Fresnel coefficients. Transport theory models describe this relationship. The change in radiance along a particular infinitesimal direction consists of two terms. The first term decreases the radiance due to absorption and scattering. The second term accounts for light scattered in the direction of ds from all other directions	No experimental proof		

Colour spectrum	Hyunjung Shim & Seungkyu Lee	Samsung Advanced Institute of Technology, Samsung Electronics	Automatic color realism enhancement for computer generated images.	Photorealism is correlated with the frequency of color occurrence: First, extracting the most representative features from the color distribution of photographs. Then, they obtained the coefficients of the most distinguishable principal axis to separate the features of photographs and those of graphics. The distribution of these coefficients constructs the color distribution of graphics and real photographs, respectively. Then, we modify the statistical characteristics (orientation, variation and the mean of color distribution) of graphics according to that of photographs.	Poor construct validity, no information on panel size or randomisation.	binomial test with corresponding P-Value	30 Participants, 600 images,
High Dynamic Range	Reinhard, Erik; Stark, Michael; Shirley, Peter; Ferwerda James: Photographic Tone Reproduction for Digital Images. University of Utah 2005.	University of Utah; Cornell University	Photographic Tone Reproduction for Digital Images	Dynamic range is the ratio between the maximum and minimum luminance values of a physical measurement. The definition can change slightly depending on if the dynamic range refers to a scene (lightness to darkness), a camera (saturation to noise), or a display (highest and lowest intensities emitted). The human eye has far greater tonal range, color depth, and dynamic range than a camera. The goal of the HDR process is to create an image that more closely approximates what the human eye can see of the original evidence.	No experimental setup, no proof or validation of theory		

High Dynamic Range & Specular Highlights	Laurence Meylan, Scott Daly and Sabine Suesstrunk	Ecole Polytechnique Federale de Lausanne (EPFL), Switzerland - Sharp Laboratories of America,	The Reproduction of Specular Highlights on High Dynamic Range Displays	20 observers participated in the experiment, 2 of them had some knowledge about the purpose of the experiment. 14 were naive observers, and 6 were experts in judging image quality. Each of them saw 330 images, which took about 25 minutes.	Thurstone's law of comparative judgment Case V - with Z-score and confidence intervals	when using an HDR display, it is preferable not to use the entire dynamic range for the diffuse component of the input image despite the reduction in mean brightness. Instead, part of the dynamic range could be used to provide a better reproduction of specular highlights and thus increase the realism of the displayed image. More importantly it confirms that at equal diffuse brightness observers significantly prefer images with brighter specular highlights.	
Detecting CG	Tian-Tsong Ng, Shih-Fu Chang	Columbia University	Classifying Photographic and Photorealistic Computer Graphic Images using Natural Image Statistics	Natural Image Statistics			
HDR Displays	Helge Seetzen, Wolfgang Heidrich, Wolfgang Stuerzlinger, Greg Ward, Lorne Whitehead, Matthew Trentacoste, Abhijeet Ghosh, Andrejs Vorozcovs	Sunnybrook Technologies, The University of British Columbia, York University	High Dynamic Range Display Systems	No experimental setup, no control mechanism, poor construct validity	Concepts to create dynamic ranges of well beyond 50,000 : 1, and a maximum intensity of 2700cd/m ² and 8500cd/m ² respectively	the maximum perceivable contrast is around 150 : 1 [Vos 1984] Scene contrast boundaries above this threshold appear blurry and indistinctive	
Luminance modulation through pulse	Conotter, V; Bodnari, E.; Boato G., Farid, H	Department of Information Engineering and Computer Science University of Trento & Dartmouth College Department of Computer Sciences, New Hampshire	Physiologically-based Detection of Computer Generated Faces in Video	Image Analysis on 12 videos of 4.5 sec with Eulerian video magnification taking as input a standard video and outputs a video in which the color variations for a given temporal frequency are magnified at a temporal frequency consistent with a typical pulse of 50-60 heart beats per minute (0.83Hz - 1.0Hz). For simplicity, the average luminance across a small extracted patch of skin is computed	Forensic mathematic method to detect realism		
Saliency	Itti, Laurent; Koch, Christoph & Niebur, Ernst	California Institute of Technology	A model of saliency-based visual attention for rapid scene analysis	Attentional model assigns attention to a wider area of the image, whereas observers pay more attention to the central region of the display.			

Attention / Inattentional Blindness	Cater k., Chalmers a., Ward g.:		Detail to attention: Exploiting visual tasks for selective rendering	Paired two-tailed-t-test with significant outcome of $p < 0.5$	96 participants plus pilot of 32 participants	When observers were focusing on a task, observers couldn't distinguish between high res and low res images. However, when the observers were simply looking at the images, the result was significantly different; i.e., the observers could distinguish that they were shown two images rendered at different qualities.	
Peripheral Centricity	L.C. Loschky, G.W. McConkie, J. Yang and M.E. Miller.	Kansas State University; University of Illinois, Urbana-Champaign; Airforce Institute of Technology	Perceptual Effects of a Gaze-Contingent MultiResolution Display Based on a Model of Visual Sensitivity.	Recall – Scores, Eyemovement tracking and image quality questionnaire - Primate visual resolution quickly degrades as one moves from the fovea into the visual periphery. Spatial sampling becomes ever more coarse with distance from the center of vision.	There were 6 paid participants, 3 female, all of whom were university students, ages 19-22, and had at least 20/20 near acuity.	Both explicit and implicit measures of perception, from subjective image quality judgments to eye fixation durations and saccade lengths, produced results consistent with predictions: As filtering is increased exponentially (iteratively halving the eccentricity to halve the cut-off frequency), fixation durations increase as a power function.	photographic images filtered with a window radius of 4.1° produced results statistically indistinguishable from that of a full, high-resolution display.
Anti-aliasing; contrast sensitivity, spatial frequency; raytracing	Don P. Mitchell	AT&T Bell Laboratories Murray Hill, New Jersey 07974	Generating antialiased images at low sampling densities,	Algorithm for multi-pass raytracing	No experiment		
Spatio-temporal acuity	M.R. Bolin and G.W. Meyer,	University of Oregon	Perceptually Based. Adaptive Sampling Algorithm. in SIGGRAPH'98, 299-309, 1998.				
Spatiotemporal Acuity	Yee, H, Pattanaik, S. Greenber, D.	Program of Computer Graphics, Cornell University	Spatiotemporal sensitivity and visual attention for efficient rendering of dynamic environments	Motion Estimation, Spatio-temporal frequency estimation were used to create an aleph map, caching diffuse indirect illumination and making use of the Human visual system to accelerate rendering processes in global illumination			

High Frequencies, Colour, Tone and Texture	Micah K. Johnson, Member, IEEE, Kevin Dale, Student Member, IEEE, Shai Avidan, Member, IEEE, Hanspeter Pfister, Senior Member, IEEE, William T. Freeman, Fellow, IEEE, and Wojciech Matusik	MIT, Harvard, Tel Aviv University and Adobe Systems, Disney Research	CG2Real: Improving the Realism of Computer Generated Images using a Large Collection of Photographs	A data-driven approach for rendering realistic imagery that uses a large collection of photographs gathered from online repositories. Given a CG image, this approach retrieves a small number of real images with similar global structure and automatically transfer color, tone, and texture from matching regions to the CG image.	Twenty subjects, between 20 and 30 years old, participated in the user study; Each participant viewed a sequence of 10 images drawn from the set of 30. Each test sequence was selected randomly, with the constraint that the sequence contained at least 3 images from each category, multiple instances of images from the same example did not appear in the sequence.	97% of the CG images as fake; 52% of the CG2Real images as fake; 17% of the real images as fake.	Texture is more important to realism than colour
Complexity, spatial frequency,	Mahesh Ramasubramanian Sumanta N. Pattanaik Donald P. Greenberg	Program of Computer Graphics Cornell University	A Perceptually Based Physical Error Metric for Realistic Image Synthesis	Based on a perceptual model which uses thresholds of visibility to focus computation on frequencies relevant to the HVS, Ramasubramanian et al. present an efficient global illumination model. Direct illumination algorithms capture most of the high spatial frequency of the image due to lighting variations. From this solution, we "precompute" the spatially-dependent component of our threshold model before the indirect illumination computation.			
Depth of Field, Stiles-Crawford Effect	Brian A. Barsky, Adam W. Bargteil, Daniel D. Garcia, Stanley A. Klein	University of California, Berkeley	Introducing Vision-Realistic Rendering	Using a Shack-Hartmann wavefront aberrometry device, the authors propose a technique to measure individual's vision and an object's space point function to blur input images accordingly	No experiment, no experimental proof		
Absence of noise	Pablo Bauszat, Martin Eisemann, Elmar Eisemann and Marcus Magnor	Computer Graphics Lab, TU Braunschweig, Germany & Delft University of Technology, Netherlands	General and Robust Error Estimation and Reconstruction for Monte Carlo Rendering	Comparing denoising filters for monte carlo renderings: Comparing Robust Denoising (RD) techniques with SURE and GID (General Image Denoising)	No control group, low construct validity, no reliability		

The Uncanny Valley	Jun'ichiro Seyama & Ruth Nagayama	University of Tokyo & Gakuin University	The Uncanny Valley: Effect of Realism on the Impression of Artificial Human Faces	Investigating the impact of realism, and eye abstraction on the Uncanny Valley	Forty-five participants (mean age 23.6 years, 22 female) observed images from morphing sequences where the eyes and head (i.e., facial regions other than the eyes) were asynchronously morphed. In the eyes first sequence; high construct validity;	Although the morphing sequences produced different tendencies, none of the four types of morphing sequences showed that an almost perfectly realistic human appearance was a sufficient condition for the uncanny valley to emerge. Experiment 2: Participants gave the lowest pleasantness score when the eyes were 100% real human and the head was 0% real human. This morphed image had higher realism than the unmorphed image of Doll A because of its real human eyes, and lower realism than the unmorphed image of Human A because of its artificial head. In the head first sequence (Figure 5b), the head was morphed first and then the eyes. Participants gave the lowest pleasantness score when the head was 100% real human and eyes were 0% real human. The uncanny valley emerged when the eyes and the head showed the largest mismatch in the degree of realism	3 Experiments: The pleasantness scores for each experiment were averaged across participants and submitted to repeated measures ANOVAs. When necessary, Bonferroni's multiple comparisons were performed. Experiment 2: one-tailed t tests, Experiment 1, $t(48) .60, p .05$; Experiment 2, $t(44) .17, p .05$.
Interaction, Tactile Collision and Feedback	Kristopher J. Blom and Steffi Beckhaus	University of Hamburg	Virtual Travel Collisions: Response Method Influences Perceived Realism of Virtual Environments	Regression Analysis, Post-Hoc comparisons with Bonferroni's correction/ Kruskal-Wallis tests. Comparing stop and slide feedback effects. The RM ANOVA of the ART data revealed a trend for the main effect of method on the realism of collision responses [$F(3) = 2.9, p = .05$]. No significant effects were revealed in the PostHoc analysis.	Sixteen users participated in this study. They were recruited on campus and were naive to the purpose of the study. The mean age was 28.8 years (SD 9.2), and 25% were female. All participants reported normal or corrected to normal vision, color vision, and stereo vision.	having a collision response increases the realism of the environment. Collisions were perceived as significantly more realistic with feedback [$W = 375, p < .05$].s. An effect of feedback on the perceived level of realism of collisions and solidity of the environment was also found.	
Sound	Elizabeth T. Davis, Kevin Scott, Jarrell Pair, Larry F. Hodges, and James Oliverio	Georgia Institute of Technology Atlanta, Georgia	Can audio enhance visual perception and performance in a virtual environment?	Presence Questionnaire, Recall Test, Forced Choice recognition text	Sixty college-aged students participated in this experiment. Each had a corrected near visual acuity of 20/20 and normal color vision	addition of audio to the visual display significantly increases the sense of presence. Proportions and 3D perspective of visual objects appeared more correct, the depth and volume of the rooms appeared more	that audio condition has a significant effect on forced-choice recognition of virtual objects in virtual rooms and that high-fidelity audio has a marginally

					for each eye. All participants reported having normal hearing.	realistic, the field of view seemed more natural or realistic, and the virtual world appeared more realistic when the visually-perceived rooms were filled with ambient sounds than when they were silent	significant effect on recall of objects in the appropriate virtual rooms
Spatial location & distribution	Jeanine K. Stefanucci & Dennis R. Proffitt	Charlottesville, Department of Psychology	Providing Distinctive Cues to Augment Human Memory	Participants were prompted to memorise word pairs in four different display conditions- A standard desktop, contextualised, spatial and within an info cockpit -	Eighty University of Virginia students (40M, 40F) participated in the experiment.	the mean recall scores were 8.80 for the Desktop group, 11.65 for the InfoCockpit group, 9.60 for the Spatial group, and 15.05 for the Context group - InfoCockpit participants remembered significantly more word pairs than participants using a standard desktop computer. Adding "location" and "place" cues to a computer enhanced participants' memory for information learned on that system.	
Bass	J. Freeman & J. Lessiter	Psychology Department Goldsmiths College	Here, there and everywhere: the effects of multichannel audio on presence	A series of two factor repeated measures ANOVAs were run for each of the dependent measures. There were two within group factors: bass (on or off) and number of channels (2 or 5), corresponding to the conditions 2.0, 2.1, 5.0 and 5.1. The questionnaire yields scores on four scales: (i) a sense of being located in a physical space depicted by the media system ('Sense of Physical Space': 19 items), (ii) a sense of involvement with the narrative/content of the mediated environment ('Engagement': 13 items), (iii) a sense of naturalness and believability of the depiction of the environment itself and events within the environment ('Ecological Validity': 5 items), and (iv) 'Negative Effects' from viewing immersive media, such as eye-strain, headache, sickness etc. (6 items)	Thirty participants were exposed to each of five audio mixes: stereo (2.0), stereo with bass (2.1), stereo 'control' matched to the volume of 2.1 (2.0control), five channel (5.0) and five channel with bass (5.1) as part of a complete audio/visual mediated experience.	irrespective of the increase in volume, adding bass to the presentation enhanced ITC-SOPI ratings of Engagement and Ecological Validity. Thus, the vibration that bass affords increased the perceived naturalness and enjoyment and interest in the presentation	Audio presentations that include a bass output provide an additional source of sensory stimulation, offering some vibration to the (rally car) stimulus. Presentations with bass will therefore receive higher ratings than those that do not include a bass output on presence and audio quality evaluations. Overall, five channel presentations were not rated more highly on presence and audio quality evaluations,
Display and Interaction Fidelity	Ryan P. McMahan, Doug A. Bowman,	Virginia Tech	Evaluating Display Fidelity and Interaction Fidelity in a	evaluate very high (360 degree, stereo) and very low (90 degree,	ANOVA and found that the level of interaction	Users had the greatest senses of presence, engagement, and	

	David J. Zielinski, and Rachael B. Brady		Virtual Reality Game	mono) levels of both display and interaction fidelity: User experience metrics completion time, damage taken, accuracy, and headshot count), objective metrics: Two way, repeated measures ANOVA, Post-Hoc Tukey HSD test	fidelity had a significant effect	usability with the highdisplay, high-interaction conditionBoth display fidelity & interaction fidelity affected the strategies participants. The significant effect display fidelity had on overall accuracy supports these observations, as low display fidelity was more accurate than high display fidelity - a fact attributed to familiarity with the display medium.	
Scale	Desney S. Tan; Darren Gergle , Peter G. Scupelli; Randy Pausch	Carnegie Mellon University	Larger Displays Improve Spatial Performance				
Lightness	Ann McNamara Alan Chalmers	University of Bristol Bristol	Comparing Real & Synthetic Scenes using Human Judgements of Lightness	ANOVA - Repeated Measures within subjects TwoAmbientBounces: (t(17) = 3.11;p < .01) Defaultimage: (t(17) = 12.4;p < .001) GuesseMaterialsimage: (t(17) = 10.7;p < .001) Raytracedimage: (t(17) =9.36;p< .001) Radiosity Image: (t(17) = 3.00; p < .01)	18 Participants Randomised Trial	TwoAmbientBounces: (t(17) = 3.11;p < .01) Defaultimage: (t(17) = 12.4;p < .001) GuesseMaterialsimage: (t(17) = 10.7;p < .001) Raytracedimage: (t(17) =9.36;p< .001) Radiosity Image: (t(17) = 3.00; p < .01)	No statistical difference for the raytraced image and radiosity from the photographic image was measured
Number of Objects, Surface Shadow, Surface Smoothness,	Paul Rademacher, Jed Lengyel Edward Cutrell Turner Whitted	Univeristy of North Carolina Chapel Hill	Measuring the Perception of Visual Realism in Images.	Logistic Regression and Repeated Measure Analysis Comparing either CG or realistic images (so not to create confounding variables) – a series of images were presented to a subject – to be rated as real or not real. Variations concerned factor under investigation. viewing angle of the images of approximately 30 degrees. The experiments were all conducted under controlled illumination.	18 subjects: Subjects all gave informed consent, and were naive to the study's purpose, non-experts in computer graphics or related visual fields, aged 20 to 50, with normal or corrected-to-normal vision.	Measuring Realism: Realism of rough surfaces were measured against realism of smooth surface. Smoothness of surface textures was measured to be a determinant of realism with strong significance.	

12.14 Expert Interviews Tabulated

Telepresence		Soft Shadow	Hard Shadow	Plain Surface	Complex Surface	Shadow Harsh	Shadow Soft	Non-Familiar	Familiar Presenter
Telepresence	Martin Shepherd AV Engineer & Project Manager	2	6	4	4	6	4	6	6
	David Buchanan Operations Manager	5	7	4	4	5	4	5	5
	Leah Glanville - AV Engineer & Project Manager	5	6	6	6	6	4	5	6
	Daren Hicks - Sales & Finance	6	4	3	6	6	6	4	6
	Kate Harris - General Manager	6	7	2	6	6	5	5	6
	Alf DeWaal - Technical Director	4	7	5	7	4	7	3	7
	Stuart McLaren - Senior Technical Manager	4	6	3	7	2	6	5	5
	Daivde Capellini - IT & Technical Support	7	6	6	6	6	7	5	6
	Federica Palma - Production Manager	5	3	2	5	4	1	3	3
	Mean	4.8888889	5.7777778	4.1111111	5.6666667		5	4.8888889	5.5555556
Telepresence	Standard Deviation	1.45296631	1.394433378	1.691481928	1.11803989	1.414213562	1.900292375	1.013793755	1.130388331
	T Value	1.324169		2.301586		0.14072		1.975757	
	P Value	0.204053	No Latency	0.035136		0.889848		0.032845	one-tailed test
	Latency			Framerate 25	Framerate 29.97	DVI	HDSDI	Harsh Exposure	Soft Exposure
	Martin Shepherd AV Engineer & Project Manager	1	7	1	7			5	7
	David Buchanan Operations Manager	2	7	4	7	4	7	4	6
	Leah Glanville - AV Engineer & Project Manager	2	7	4	7	5	6	4	6
	Daren Hicks - Sales & Finance	1	6	4	6	6	6	3	6
	Kate Harris - General Manager	6	7	5	6	6	7	7	5
	Alf DeWaal - Technical Director	1	7	2	7	6	7	5	7
Telepresence	Stuart McLaren - Senior Technical Manager	1	6	3	5			3	6
	Daivde Capellini - IT & Technical Support	5	7					6	6
	Federica Palma - Production Manager	1	7	1	7	4	3	2	5
	Mean	2.2222222	6.7777778	3	6.5	5.16666667	6	4.333333333	6
	Standard Deviation	1.92209377	0.440958552	1.511857892	0.755928946	0.98319208	1.549193338	1.58113883	0.707106781
	T Value	6.930265		5.85662		2.558409		2.886751	
	P Value	0.00001		4.20E-05		0.03373		0.005366	

12.15 Meta-Analysis – Master Candidate List

Table 9-1: Meta-Analysis Master Candidate List – Recording Cues

1. Frame rate / Sampling rate / Shutter speed	Two-interval forced-choice experiment. One interval contained a vertical line which moved smoothly to the right or left, the other interval contained a line moving at the same velocity but sampled at a rate of M^{-1} . The observer was asked to choose which interval contained the sampled version, and was informed after each trial whether the choice was correct.	3 experiments: Sample size 2 subjects with 25 trials per experiment. Poor construct validity, strong analytical argumentation.	Measuring: Accuracy; Distance estimation was found to be very accurate for flat and continuous surfaces up to 20 m, but far space has received very little attention: Eye collects spatial information from a single vantage point as a result depth requires interpretation from the proximal stimulus. A considerable difference between pictorial and visual space was attested	Andrew B. Watson, Albert Ahumada, Jr., and Joyce E. Farrell Amea Research Center Moffett Field, California The Window of Visibility: A Psychophysical Theory of Fidelity in Time-Sampled Visual ~ Motion Displays. National Aeronautics and Space Administration Scientific and Technical Information Branch. NASA Technical Paper 221 I 1983
2. Vanishing lines as depth cues	Comparison of pictorial space with 35mm, and visual space and perspective estimations.	Sample size 4 subjects; poor construct validity, strong mathematic-theoretic argumentation;	Measuring Accuracy: Distance estimation was found to be very accurate for flat and continuous surfaces up to 20 m, but far space has received very little attention: Eye collects spatial information from a single vantage point as a result depth requires interpretation from the proximal stimulus. A considerable difference between pictorial and visual space was attested	Casper J. Erkelens: The extent of visual space inferred from perspective angles. i-Perception (2015) volume 6, pages 5–14
3. / Field of View / Life-sized proportions and sizing /	Wilcoxon Signed Ranks tests for paired comparisons, Friedman tests for comparing several related groups, and factorial repeated-measures ANOVAs on	24 students from Delft University – median 26.15 (SD=2.18), all naïve with respect to hypothesis.	Measuring Presence, Distance Perception; Displacement effect is smaller than predicted, human visual system compensates for displacement. When the CoP	Ling Y, Neftci HT, Brinkman W-P, Qu C, Heynderickx I (2013) The Effect of Perspective on Presence and Space Perception. PLoS ONE 8(11): e78513. doi:10.1371/journal.pone.0078513

	aligned rank data for non-parametric factorial analysis		is at the vantage point, a larger FoV increases presence; monocular viewing results in a higher degree of presence - the sense of presence can be predicted by the perceived layout of the virtual environment.	
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4. Divergence of CoP from vantage point and presence	Wilcoxon Signed Ranks tests for paired comparisons, Friedman tests for comparing several related groups, and factorial repeated-measures ANOVAs on aligned rank data for non-parametric factorial analysis; Spearman correlation analysis; Cronbach's α ranging from 0.92 to 0.98	24 students from Delft University – median 26.15 (SD=2.18), all naïve with respect to hypothesis.	Measuring Presence, Distance Perception; Perceived distortions in the perspective are associated with a reduction in experienced presence. With vantage points in front of the screen center, no significant distortion is found for correct perspective. Less depth is found if the CoP is behind the vantage point, more depth when it is in front. Participants perceive a less distorted image when shifting the CoP to the center of the screen. No significant difference is found between a CoP at the vantage point and a CoP at the screen center. More presence was reported for the stimulus with a preferred CoP behind the vantage point than for the stimulus with a preferred CoP in front of the vantage point.	Ling Y, Neffs HT, Brinkman W-P, Qu C, Heynderickx I (2013) The Effect of Perspective on Presence and Space Perception. PLoS ONE 8(11): e78513. doi:10.1371/journal.pone.0078513
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5. Peripheral Centricity	Recall – Scores, Eyemovement tracking and	There were 6 paid participants, 3	Measuring Image Quality: Primate visual	L.C. Loschky, G.W. McConkie, J. Yang and M.E. Miller. Perceptual Effects of a Gaze-Contingent
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	image quality questionnaire: Both explicit and implicit measures of perception, from subjective image quality judgments to eye fixation durations and	female, all of whom were university students, ages 19-22, and had at least 20/20 near acuity.	resolution quickly degrades as one moves from the fovea into the visual peripher. Spatial sampling becomes ever more coarse with distance from the center of vision. photographic images filtered with a window radius of 4.1° produced results statistically indistinguishable from that of a full, high-resolution display.	MultiResolution Display Based on a Model of Visual Sensitivity. In Advanced Displays and Interactive Displays Fifth Annual Symposium, 2001, pp. 53–58.
6. High spatial Frequencies, Colour, Tone and Texture	Realism questionnaire following image comparison of 30. Each participant viewed a sequence of 10 images drawn from the set of 30. Each test sequence was selected randomly, with the constraint that the sequence contained at least 3 images from each category, multiple instances of images from the same example did not appear in the sequence.	Twenty subjects, between 20 and 30 years old, participated in the user study;	Measuring Realism: 97% of the CG images as fake; 52% of the CG2Real images as fake; 17% of the real images as fake. Texture is more important to realism than colour	Micah K. Johnson, Member, IEEE, Kevin Dale, Student Member, IEEE, Shai Avidan, Member, IEEE, Hanspeter Pfister, Senior Member, IEEE, William T. Freeman, Fellow, IEEE, and Wojciech Matusik. MIT, Harvard, Tel Aviv University and Adobe Systems, Disney Research. CG2Real: Improving the Realism of Computer Generated Images using a Large Collection of Photographs

7. Softness of Shadows	<p>Logistic Regression and Repeated Measure Analysis Comparing either CG or realistic images (so not to create confounding variables) – a series of images were presented to a subject – to be rated as real or not real. Variations concerned factor under investigation. viewing angle of the images of approximately 30 degrees. The experiments were all conducted under controlled illumination.</p>	<p>18 subjects: Subjects all gave informed consent, and were naïve to the study's purpose, non-experts in computer graphics or related visual fields, aged 20 to 50, with normal or corrected-to-normal vision.</p>	<p>Measuring Realism: Visual realism varied as a result of shadow softness. Perceived realism was maximized with respect to shadow softness in the neighborhood of 5.21 degrees of penumbra angle. Any additional increase in softness had diminishing returns.</p> <p>The sharpest shadows were rated the lowest in realism.</p>	<p>Paul Rademacher, Jed Lengyel Edward Cutrell Turner Whitted - University of North Carolina at Chapel Hill - Microsoft Research</p> <p>Measuring the Perception of Visual Realism in Images. 2001</p>
8. Surface Smoothness	<p>Logistic Regression and Repeated Measure Analysis Comparing either CG or realistic images (so not to create confounding variables) – a series of images were presented to a subject – to be rated as real or not real. Variations concerned factor under investigation. viewing angle of the images of approximately 30 degrees. The experiments were all conducted under controlled illumination.</p>	<p>18 subjects: Subjects all gave informed consent, and were naïve to the study's purpose, non-experts in computer graphics or related visual fields, aged 20 to 50, with normal or corrected-to-normal vision.</p>	<p>Measuring Realism: Realism of rough surfaces were measured against realism of smooth surface. Smoothness of surface textures was measured to be a determinant of realism with strong significance.</p>	<p>Paul Rademacher, Jed Lengyel Edward Cutrell Turner Whitted - University of North Carolina at Chapel Hill - Microsoft Research</p> <p>Measuring the Perception of Visual Realism in Images. 2001</p>

9. Number and Variety of Objects	Logistic Regression and Repeated Measure Analysis Comparing either CG or realistic images (so not to create confounding variables) – a series of images were presented to a subject – to be rated as real or not real. Variations concerned factor under investigation. viewing angle of the images of approximately 30 degrees. The experiments were all conducted under controlled illumination.	10 subjects: Subjects all gave informed consent, and were naïve to the study's purpose, non-experts in computer graphics or related visual fields, aged 20 to 50, with normal or corrected-to-normal vision.	Measuring Realism: No significant effect was found – the number of objects or the variety of objects / complexity of the scene does not determine realism in a scene.	Paul Rademacher, Jed Lengyel Edward Cutrell Turner Whitted - University of North Carolina at Chapel Hill - Microsoft Research Measuring the Perception of Visual Realism in Images.2001
10. Time / Latency	Comparing 5 virtual museums by means of a Presence questionnaire a "virtual presence" index (denoted PM) was calculated by averaging the results of the respective questions per questionnaire and museum. The resulting PM data are then plotted in the form of a histogram for visual inspection of differences in the data distribution for the five museums.	A total of 46 volunteers (males and females with ages from 19-37)	Measuring Presence: 3-D spaces and real time navigation results in the greater feeling of presence in a virtual interface. In addition to this, some recent web technologies to enhance interaction, such as Macromedia Flash, in combination with embedded sound and/or video add to this feeling of presence significantly.	Styliani Sylaiou, Athanasios Karoulis, Yiannis Stavropoulos and Petros Patias: Presence-Centered Assessment of Virtual Museums' Technologies. DESIDOC Journal of Library and Information Technology, Vol. 28, No. 4, July 2008, pp. 55-62

Table 9-2: Meta-Analysis Master Candidate List – Lighting Cues

11.Specular highlights	EyeMovement Analysis - Kolmogorov–Smirnov test, Friedman test	Sample size of 16, multiple comparison for paired samples	Measuring Realism. Results: Specular highlights are positively correlated to realism perception	Elhelw, M., Nicolaou, M., Chung, A., Yang, G.-Z., and Atkins, M. S. 2008. A gaze-based study for investigating the perception of visual realism in simulated scenes. ACM Trans. Appl. Percpt. 5, 1, Article 3 (January 2008), 20 pages.
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12. Distractor presence	Eye-tracking software and matlab application; paired T-Tests and one sample T-tests	8 naïve observers aged 19-21	Measuring Latency and Accuracy: Increasing latency of saccade movement up to 200ms due to presence of a distractor improves saccade accuracy by increasing fixation related activation.	Eugene McSorley; Alice G Cruickshank: Evidence that indirect inhibition of saccade initiation improves saccade accuracy. i-Perception (2010) volume 1, pages 73 – 82
13. Number of Light sources	Logistic Regression and Repeated Measure Analysis Comparing either CG or realistic images (so not to create confounding variables) – a series of images were presented to a subject – to be rated as real or not real. Variations concerned factor under investigation. viewing angle of the images of approximately 30 degrees. The experiments were all conducted under controlled illumination.	7 subjects: Subjects all gave informed consent, and were naïve to the study's purpose, non-experts in computer graphics or related visual fields, aged 20 to 50, with normal or corrected-to-normal vision.	Measuring Realism: No significant effect was found – the number of light sources creating shadows does not determine realism in a scene.	Paul Rademacher, Jed Lengyel Edward Cutrell Turner Whitted - University of North Carolina at Chapel Hill - Microsoft Research Measuring the Perception of Visual Realism in Images. Proceedings of the Eurographics Workshop in London, United Kingdom, June 25–27, 2001
14. Lightness and Rendering	ANOVA - Repeated Measures within subjects Two Ambient Bounces: $t(17) = 3.11; p < .01$ Default image: $t(17) = 12.4; p < .001$ Guessed Materials image: $t(17) = 10.7; p < .001$ Raytraced image: $t(17) = 9.36; p < .001$ Radiosity Image: $t(17) = 3.00; p < .01$	18 Participants Randomised Trial	Measuring Lightness and Realism: No statistic difference between photograph and Renderings with 2 ambient bounces: $t(17) = 3.11; p < .01$ Default image: $t(17) = 12.4; p < .001$ raytraced image: $t(17) = 9.36; p < .001$ or a radiosity computed image: $t(17) = 3.00; p < .01$	McNamara, Ann & Chalmers, Alan: Comparing Real & Synthetic Scenes using Human Judgements of Lightness. Department of Experimental Psychology University of Bristol Bristol. Book Section 2000 Rendering Techniques 2000 Eurographics E Péroche, Bernard E Rushmeier, Holly R: - Springer Vienna
15. Lighting Design	two questionnaires: A presence questionnaire and a questionnaire investigating subjective responses to lighting	A total of 36 participants were exposed to each experimental visual	Dependent Variable: Presence; positive correlation between presence & impressions of lighting ('warm', 'comfortable', 'spacious', etc.) associated to high-quality, full-shadow accuracy rendering condition.	Katerina Mania & Andrew Robinson: The Effect of Quality of Rendering on User Lighting Impressions and Presence in Virtual Environments. VRCAI '04 Proceedings applications in ind Pages 200-205

Table 9-3: Meta-Analysis Master Candidate List – Image Transfer Cues

<p>16. Frame Rate</p>	<p>Univariate General Linear Model with repeated measure technique - investigating the effect of the condition while taking into account inter-subject variation, order effects, and the effects of factors that change from exposure to exposure such as loss of balance on the 1.5-inch ledge.</p>	<p>Frame Rate: 33 participants (average age 22.3; $\sigma = 3.6$; 8 female, 25 male) entered the VE four times on one day and were presented the same VE with a different frame rate each time. Subjects entered the VE four times on one day and were presented the same VE with a different frame rate each time. The four frame rates were 10, 15, 20, and 30 frames-per-second (FPS). Subjects were counterbalanced as to the order of presentation of the four framerates.</p>	<p>Measuring Presence: The hypothesis assumed that as frame rate increases from 10, 15, 20, 30 frames/second, presence increases. For frame rates of 15 frames/second and above, the hypothesis was confirmed. It was confirmed with statistical significance for 15 to 20 FPS and 15 to 30 FPS though not statistically significant was in the same direction. 10 FPS gave anomalous results on all measures except Reported Presence, which increased monotonically with frame rate with no statistical significance.</p>	<p>Meehan, Michael; Insko, Brent; Whitton, Mary; Brooks, Frederick P Jr.; Physiological Measures of Presence in Stressful Virtual Environments. Proceeding Siggraph 2002 CM Transactions on Graphics (TOG) - Proceedings of ACM SIGGRAPH 2002 Volume 21 Issue 3, July 2002</p> <p>Proceedings of the 29th annual conference on Computer graphics and interactive techniques Pages 645-652</p>
<p>17. High Dynamic Range / Compression</p>	<p>Thurstone's law of comparative judgment Case V - with Z-score and confidence intervals</p>	<p>20 observers participated in the experiment, 2 of them had some knowledge about the purpose of the experiment. 14 were naive observers, and 6 were experts in judging image quality.</p>	<p>Measuring preference: Equal diffuse brightness observers significantly prefer images with brighter specular highlights. When using an HDR display, it is preferable not to use the entire dynamic range for the diffuse component of the input image despite the reduction in mean brightness. Instead, part of the dynamic range needs to provide a better reproduction of specular highlights increasing realism of displayed image.</p>	<p>Laurence Meylan, Scott Daly and Sabine Suesstrunk: The Reproduction of Specular Highlights on High Dynamic Range Displays. IS&T/SID 14th Color Imaging Conference (CIC). 2006.</p>

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Table 9-4: Meta-Analysis Master Candidate List – Image Quality Cues

18. Shading, Colour, resolution, Holistic Form	Signal detection theory, Inferential statistical tests: ANOVA followed up with T-tests or post-hoc tests	51 asian undergrad students aged 19-23 with normal or corrected to normal visual acuity from Ningbo University in China took part – 3 x image types x 4 manipulation conditions tested on 1,260 pairs of images	Measuring Realism: Both piece-meal and holistic processing is involved in image analysis; shading is more important than colour in holistic processing, holistic processing more dominant when resolution is lower; context and eyes are most influential for the analysis of facial realism,	Shaojing Fan, Tian-Tsong Ng, Jonathan S. Herberg, Bryan L. Koenig, Cheston Y.-C. Tan, and Rangding Wang. 2014. Human perception of visual realism for photo and computer-generated face images. ACM Trans. Appl. Percept. 11, 2, Article 7 (May 2014), 21 pages.
19. High Fidelity Display / FOV	ANOVA - evaluate very high (360 degree, stereo) and very low (90 degree, mono) levels of both display and interaction fidelity: User experience metrics completion time, damage taken, accuracy, and headshot count), objective metrics: Two way, repeated measures ANOVA, Post-Hoc Tukey HSD test	24 participants between 18 to 26 years old with a mean age of 20	Measuring Presence: Users had the greatest senses of presence, engagement, and usability with the high-display, high-interaction condition. Both display fidelity & interaction fidelity affected the strategies participants. The significant effect display fidelity had on overall accuracy supports these observations, as low display fidelity was more accurate than high display fidelity - a fact attributed to familiarity with the display medium.	Ryan P. McMahan, Doug A. Bowman, David J. Zielinski, and Rachael B. Brady: Evaluating Display Fidelity and Interaction Fidelity in a Virtual Reality Game. Journal IEEE Transactions on Visualization and Computer Graphics archive Volume 18 Issue 4, April 2012 Pages 626-633

20. Field of View/ Display Size	Wilcoxon Signed Ranks tests for paired comparisons, Friedman tests for comparing several related groups, and factorial repeated-measures ANOVAs on aligned rank data for non-parametric factorial analysis	24 students from Delft University – median 26.15 (SD=2.18), all naïve with respect to hypothesis.	Measuring Presence: A projector displaying a life-size virtual classroom evokes a higher level of presence than a TV displaying a life-size. No difference in presence is found between the TV displaying a life-size scene and a scaled-down scene - not spatial resolution, but rather the difference in display size dominates the difference in presence between the two display systems.	Ling Y, Nefs HT, Brinkman W-P, Qu C, Heynderickx I (2013) The Effect of Perspective on Presence and Space Perception. PLoS ONE 8(11): e78513. doi:10.1371/journal.pone.0078513
21. Colour Spectrum	binomial test with corresponding P-Value. Poor construct validity, no information on panel size or randomisation.	30 Participants, 600 images,	Measuring Realism: Photorealism is correlated with the frequency of color occurrence: First, the research team extracted the most representative features from the color distribution of photographs. Then, they obtained the co-efficients of the most distinguishable principal axis to separate the features of photographs and those of graphics. The distribution of these coefficients constructs the color distribution of graphics and real photographs, respectively. Then, the team modified the statistical characteristics (orientation, variation and the mean of color distribution) of graphics according to that of photographs.	Hyunjung Shim & Seungkyu Lee. Samsung Advanced Institute of Technology, Samsung Electronics. Automatic color realism enhancement for computer generated images. Computers & Graphics Volume 36, Issue 8, December 2012, Pages 966–973
17/22. High Dynamic Range	Thurstone's law of comparative judgment Case V - with Z-score and confidence intervals	20 observers participated in the experiment, 2 of them had some knowledge about the purpose of the experiment. 14 were naïve observers, and 6 were experts in judging image quality.	Measuring preference: Equal diffuse brightness observers significantly prefer images with brighter specular highlights. When using an HDR display, it is preferable not to use the entire dynamic range for the diffuse component of the input image despite the reduction in mean brightness. Instead, part of the dynamic range needs to provide a better	Laurence Meylan, Scott Daly and Sabine Suesstrunk: The Reproduction of Specular Highlights on High Dynamic Range Displays. IS&T/SID 14th Color Imaging Conference (CIC)

			reproduction of specular highlights increasing realism of displayed image.	
23. Display Size	RM-ANOVA; Post-Hoc preference Tests; Guilford Zimmerman Spatial performance task tests (Experiment 1) and Shape Test (Experiment 2)	Experiment 1: Twenty-four college students, who were intermediate to experienced computer users, participated in the study. We screened users to be fluent in English and to have normal or corrected-to-normal eyesight. The average age of users was 25.4 (25.5 for males, 25.3 for females), ranging from 19 to 32 years of age. Twenty-four (14 female) college students, who did not participate in the first study, participated in this study. As before, we screened users to have normal or corrected-to-normal eyesight. The average age of users was 24.1 (25.4 for males, 23.2 for females), ranging from 18 to 56 years of age.	Measuring Performance and Satisfaction Levels: Experiment 1: Comparing spatial orientation task performance (Guilford-Zimmerman Test) on large scale and small scale displays: 76" wide by 57" tall. The image on the monitor was adjusted to be exactly 14" wide by 10.5, controlling for viewing angle, frame rate & resolution. Experiment 2: User satisfaction ratings support performance results: users performing the Guilford-Zimmerman test significantly preferred large displays to small. Users performing this task in the 2 nd study significantly preferred large displays for 'Confidence in Rotation' and 'Overall Performance,' as compared to users doing the Shape test.	Desney S. Tan; Darren Gergle, Peter G. Scupelli; Randy Pausch: Larger Displays Improve Spatial Performance. CHI 2003, April 5–10, 2003, Ft. Lauderdale, Florida, USA.

Table 9-5: Meta-Analysis Master Candidate List –SoundCues

24. Role of Bass Role of 5.1 sound	ITC-SOPI questionnaire with 44 items on a 1-5 scale and Media Experience Questionnaire over 18 items; 2 factor ANOVA	Sample size of 30	Measuring Presence Findings: Base significantly enhances presence experiences (sense of physical space and engagement); No significant findings on 5.1 surround sound over stereo sound other than enhancement of physical space	Freeman & Lessiter; Proceedings of the 2001 International Conference on Auditory Display, Espoo, Finland, July 29-August 1, 2001
25. Cross-modal auditoryvisual perception phenomena	Quality Percept Ratings. Combined Data: One Sample Sign Tests for Visual-Only Quality Percept of Combined Auditory-Visual Displays. Combined Data: One Sample Sign Tests for Auditory-Only Quality Percept of Combined Auditory-Visual Displays. Post experiment survey,	108 participants (59male, 49 female) = average age of 36.1 years. All subjects were required to have 20/20 vision and normal hearing.	Dependent Variable: Presence 1) whether asked to specifically attend to both auditory and visual modalities or asked to attend to only one modality, 2) whether manipulating visual display pixel resolution or Gaussian noise level, 3) whether manipulating auditory display sampling frequency or Gaussian noise level, or 4) whether an auditory-visual display is tightly or loosely coupled, cross-modal auditory visual perception phenomena exist.	Russel Storms: Auditory visual cross modal perception phenomena. Naval Postgraduate School. Monterey California. 1998.
26. Ambient sound and sound fidelity	Presence Questionnaire, Recall Test, Forced Choice recognition text	Sixty college-aged students participated in this experiment. Each had a corrected near visual acuity of 20/20 and normal color vision for each eye. All participants reported having normal hearing.	Dependent Variable: Presence, 3D perception; Addition of audio to the visual display significantly increases the sense of presence. Proportions and 3D perspective of visual objects appeared more correct, the depth and volume of the rooms appeared more realistic, the field of view seemed more natural or realistic, and the virtual world appeared more realistic when the visually-perceived rooms were filled with ambient sounds than when they were silent	Elizabeth T. Davis, Kevin Scott, Jarrell Pair, Larry F. Hodges, and James Oliverio: Can Audio enhance perception in a virtual environment? Proceedings of the 43rd Annual Meeting of the Human Factors and Ergonomics Society. 1999.

Table 9-6: Meta-Analysis Master Candidate List –Social Cues

<p>27. Anthropomorphism</p>	<p>Meta-Analysis: Effect Size Calculations and Significance Value Calculations – separating</p>	<p>25 Studies (average year of publication 2001.96)</p>	<p>Effect of Anthropomorphism; While most studies have found that interface agents have positive effects on task performance, these effects are overall actually quite small. A visual representation of an agent leads to more positive social interaction than not having a visual representation</p>	<p>Nick Yee, Jeremy N. Bailenson, Kathryn Rickertsen: A Meta-Analysis of the Impact of the Inclusion and Realism of Human-Like Faces on User Experiences in Interfaces. Department of Communication Stanford University, Stanford, CA</p>
<p>28. Behavioral Realism/ Type of gaze</p>	<p>A between-groups, two-by-two factor design was employed with the two factors being the degree of avatar photorealism and behavioral realism, specifically in terms of eye gaze behavior. Participants did not meet prior to the experiment, to avoid the possibility of any first impressions influencing the role of the avatar in the conversation. The first person to arrive was assigned to the Cave, the second to the HMD in an adjacent room. Since there were two different roles in the scenario, the role played by the participant in each interface was randomized to avoid introducing constant error. After filling out a background questionnaire, participants read the scenario. They then each performed a navigation training task in the Cave or HMD. doors separating the virtual training rooms from the central meeting room were opened, microphones were activated. Maximum of 10 minutes for</p>	<p>Population 48 participants were paired with someone of their own gender and assigned randomly to one of the four conditions. They did not know their conversation partner prior to the experiment, and were not allowed to meet beforehand. A gender balance was maintained across the four conditions, as illustrated in Table 1. The reason for this is that there is evidence [3] that males and females can respond differently to nonverbal behaviors, particularly in the case of eye gaze cues.</p>	<p>Dependent Variable: Perceived Quality of Communication: The study compared inferred-gaze and random gaze models previously tested in a non-immersive setting: Independent of head-tracking, inferred eye animations can have a significant positive effect on participants' responses to an immersive interaction</p>	<p>Maia Garau, Mel Slater, Vinoba Vinayagamoorthy, Andrea Brogni, Anthony Steed, M. Angela Sasse: The Impact of Avatar Realism and Eye Gaze Control on Perceived Quality of Communication in a Shared Immersive Virtual Environment. CHI 2003, April 5–10, 2003, Volume No. 5, Issue No. 1</p>

	conversation. The session concluded with a postquestionnaire and a semi-structured interview			
29. Attention / Inattentional Blindness	Paired two-tailed-t-test with significant outcome of $p < 0.5$	96 participants plus pilot of 32 participants	Dependent Variable: Image Quality. When observers were focusing on a task, observers could not distinguish between high res and low res images. However, when the observers were simply looking at the images, the result was significantly different; i.e., the observers could distinguish that they were shown two images rendered at different qualities.	Cater, K. Chalmers, A. Ward, G.: Detail to attention: Exploiting visual tasks for selective Rendering. Proceedings of the 2003 EUROGRAPHICS Symposium on Rendering (2003), Christensen P., Cohen-Or D., (Eds.), EUROGRAPHICS, pp. 270–280
30. Causal perception / realism and perception	Witmer & Singer PQ subset of 10 questions with focus on control – Text analysis & evaluation using ANOVA and Tukey HSD post-hoc tests and linguistic description analysis following Wolf.	Total of 53 subjects in 3 groups. Group 1 realistic effects 16 subjects (average age 22.6), Group 2 unrealistic causal effects with 20 subjects (average age 27.8;) and Group 3 with 17 subjects (average age 26.9;) – the reference group.	Dependent Variable: Presence; Presence score for realistic causality significantly higher than unrealistic causality	Marc Cavazza* Jean-Luc Lugin Causal Perception in Virtual Reality and its Implications for Presence Factors University of Teesside Presence, Vol. 16, No. 6, December 2007, 623– 642 © 2007
31. Interaction, Tactile Collision and Feedback	Regression Analysis, Post-Hoc comparisons with Bonferroni's correction/ Kruskal-Wallis tests. Comparing stop and slide feedback effects. The RM ANOVA of the ART data revealed a trend for the main effect of method on the realism of collision responses [$F(3) = 2.9$, $p = .05$]. No significant effects were revealed in the PostHoc analysis.	16 users participated in this study. They were recruited on campus and were naive to the purpose of the study. The mean age was 28.8 years (SD = 9.2), and 25% were female. All participants reported normal or corrected to normal vision, color vision, and stereo vision.	Dependent Variable: Realism; Having a collision response increases the realism of the environment. Collisions were perceived as significantly more realistic with feedback [$W = 375$, $p < .05$]. An effect of feedback on the perceived level of realism of collisions and solidity of the environment was also found.	Kristopher J. Blom and Steffi Beckhaus: Virtual Travel Collisions: Response Method Influences Perceived Realism of Virtual Environments. ACM Trans. Appl. Percept. 10, 4, Article 25 (October 2013), 19 pages
32. Gaze & Personal Space	The questionnaire was used in an experiment investigating personal space. Participants ($n=50$,	Total of 50 subjects. Reliability: Internal consistency $\alpha = .83$. Validity:	Dependent Variable: Realism and Social Presence: For women, a significant correlation was found between	Bailenson, J.N., Blascovich, J., Beall, A.C., & Loomis, J.M. (2001). Equilibrium revisited: Mutual gaze and personal

	<p>within-subjects design) were immersed in a virtual room in which a virtual male agent stood. In each trial they were asked to walk up to the agent and remember certain features and labels on the front and back of the agent's shirt. The position and orientation of participants were tracked. The photographic realism of the agent's face and the degree of mutual gaze between agent and participant were varied. After the experience was over, participants once more put on the HMD to rate the two different avatar types for social presence. A Likert-type scale (-3 to +3) was shown over the agent's head. Participants looked at the agent and the scale while the experimenter read out the questions. Internal consistency was $\alpha=.83$.</p>	<p>The results obtained with the questionnaire were similar to an interpersonal distance measure. The correlation between the measures is not reported. Sensitivity: Questionnaire scores discriminated between different conditions (degrees of gaze).</p>	<p>degree of gaze and social presence, but not for men. No effect of realism was found. The same pattern of results was found for interpersonal distance. All participants maintained more space around agents than they did around similarly sized and shaped but nonhuman-like objects. Female participants maintained more interpersonal distance between themselves and agents who engaged them in eye contact (that is, mutual gaze behavior) than between themselves and agents who did not engage them in eye contact, whereas male participants did not.</p>	<p>space in virtual environments. Presence: Teleoperators and Virtual Environments, 10, 583-598.</p>
<p>33. Familiarity with the Environment</p>	<p>E1: Heart-Rate Analysis, ANOVA, Skin Conductance, Presence questionnaire – A between-subjects experiment to assess the potential differences in presence evoked by the three different immersive virtual environment conditions. Participants were asked to perform a series of welldefined tasks along a delimited path, first in a control version of the environment, and then in a stressful variant in which the floor around the marked path was cut away to reveal a 20-ft drop. E2: Pre-test</p>	<p>E1: A total of 40 participants (35 male, five female), ranging in age from 18 to 38 (average age $\frac{1}{4}$ 21.58 6 4.09) – Data of 9 participants had to be excluded for varying reasons (loss of signal, experimenter error, stopping trial)</p> <p>E2: 24 (10 female, 14 male) participants - ranging in age from 18 to 35 (l $\frac{1}{4}$ 21.3 6 3.8). None of the participants had previously been involved with any virtual reality studies in</p>	<p>Dependent Variable: Distance Estimation; Participants made significantly greater distance estimation errors in the unfamiliar room environment than in the replica room environment. Participants tend to experience a greater sense of presence, at least initially, when immersed in a virtual environment that is a photorealistic replica of their concurrently occupied, real-world environment, than when immersed in a photorealistically rendered virtual environment that represents a different place that is unfamiliar to them, or when immersed in a virtual environment</p>	<p>Lane Phillips, Victoria Interrante* Michael Kaeding Brian Ries; Lee Anderson: Correlations Between Physiological Response, Gait, Personality, and Presence in Immersive Virtual Environments. Presence, Vol. 21, No. 2, Spring 2012, Massachusetts Institute of Technology. P. 119–141.</p>

	questionnaire to assess a variety of personality measures, randomly immersed participants in either the photorealistic replica or photo-realistic non-replica environment to assess accuracy of egocentric distance judgements in the virtual environment. Post-hoc presence questionnaire.	the lab.	that is nonphotorealistically rendered, even when they are told that it represents an exact replica of the real environment that they are concurrently occupying.	
34. Multiple Exposure	Univariate General Linear Model with repeated measure technique - investigating the effect of the condition while taking into account inter-subject variation, order effects, and the effects of factors that change from exposure to exposure such as loss of balance on the 1.5-inch ledge.	(average age 22.3; $\sigma = 3.6$; 8 female, 25 male) entered the VE twelve times (over four days) in order to study whether the presence inducing power of a VE declines, or becomes unusably small, over multiple exposures.	Dependent Variable: Presence; Significant decreases in each presence measure were reported (reported and physiological) in either this experiment or one of the subsequent two experiments (see Table 3). However, none of the measures decreased to zero nor did any become unusably small. The findings supported the hypothesis that all presence measures decrease over multiple exposures to the same VE, but not to zero.	Meehan, Michael; Insko, Brent; Whitton, Mary; Brooks, Frederick P Jr.; Physiological Measures of Presence in Stressful Virtual Environments. Proceeding Siggraph 2002, ACM Transactions on Graphics (TOG) - Proceedings of ACM SIGGRAPH 2002 Volume 21 Issue 3, 2002 Proceedings of the 2002 annual conference on Computer graphics & interactive techniques Pages 645-652

Table 9-7: Meta-Analysis Master Candidate List –Suspension of Disbelief

35. Uncanny Valley	Within group experiment, four clusters of audio-visual stimuli robot figure-synthetic, human-human; robot-human; human-robot: Questionnaire on 7 point Likert scale with two way repeated ANOVA - Cronbach's alpha's ranged from 0.70 to 0.88	48 undergrad students – mean age 21.2 (SD = 3.7).	Dependent Variable: Pleasure; Incongruence in a human's face and voice can elicit eeriness;	Wade J Mitchell, K A Szerszen, A S Lu, P W Schermerhorn, M Scheutz, K F MacDorman A mismatch in the human realism of face and voice produces an uncanny valley. i-Perception (2011) volume 2, pages 10 – 12
36. Uncanny Valley	3 Experiments: The pleasantness scores for each experiment were	Forty-five participants (mean age 23.6 years, 22	Dependent Variable: Subjective Impressions (Warmth,	Jun'ichiro Seyama* Department of Psychology Faculty of Letters

	<p>averaged across participants and submitted to repeated measures ANOVAs. When necessary, Bonferroni's multiple comparisons were performed. Experiment 2: one-tailed t tests, Experiment 1, $t(48) .60, p .05$; Experiment 2, $t(44) .17, p .05$.</p>	<p>female) observed images from morphing sequences where the eyes and head (i.e., facial regions other than the eyes) were asynchronously morphed. In the eyes first sequence</p>	<p>Eeriness,...) Experiment1: Although the morphing sequences produced different tendencies, none of the four types of morphing sequences showed that an almost perfectly realistic human appearance was a sufficient condition for the uncanny valley to emerge Experiment2: Participants gave the lowest pleasantness score when the eyes were 100% real human and the head was 0% real human. This morphed image had higher realism than the unmorphed image of Doll A because of its real human eyes, and lower realism than the unmorphed image of Human A because of its artificial head. In the head first sequence (Figure 5b), the head was morphed first and then the eyes. Participants gave the lowest pleasantness score when the head was 100% real human and eyes were 0% real human. The uncanny valley emerged when the eyes and the head showed the largest mismatch in the degree of realism</p>	<p>University of Tokyo 7-3-1 Hongo, Bunkyo-ku Tokyo 113-0033, Japan Ruth S. Nagayama Department of Humanities and Social Sciences Shizuoka Eiwa Gakuin University. The Uncanny Valley: Effect of Realism on the Impression of Artificial Human Faces. Presence, Vol. 16, No. 4, August 2007, 337–351 © 2007 by the Massachusetts Institute of Technology</p>
37. Uncanny Valley	<p>Repeated-measures ANOVA was conducted on each of the subjective ratings and behavioral DVs with human Likeness as the IV</p>	<p>Sixty subjects (28 male) with ages ranging from 18 to 28 years ($M=19:13$, $SD=1:48$)</p>	<p>Dependent Variable: Interest, Avoidance; people attempt to avoid unnerving encounters with highly humanlike robots (via both situation targeted strategies and attentional deployment) more so than encounters with less humanlike or human agents.</p>	<p>Megan Strait, Lara Vujovic, Victoria Floerke, Matthias Scheutz, and Heather Urry: Too Much Humanness for Human-Robot Interaction: Exposure to Highly Humanlike Robots Elicits Aversive Responding in Observers. CHI '15: Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems</p>